

# **Summary**

## **Overview of the Jet / Surface Interaction Test (JSIT1)**

This material was presented at the Acoustics Technical Working Group Meeting on April 22, 2011. It provides an overview of an experiment called the Jet / Surface Interaction Test which was conducted to expand the database available regarding how a planar surface interacts with a jet to shield and/or enhance the jet noise. This presentation focuses on data obtained during Phase 1 of the test, JSIT1, which was conducted using the Small Hot Jet Acoustic Rig located in the Aeroacoustics Propulsion Lab at NASA GRC during January and February, 2011. A second phase of the test, JSIT2, is planned for 2012.

There were two parts of the phase 1 test. In part 1, known as the shielding surface part of the test, a planar surface was placed between the jet and the microphones. In part 2, the reflecting surface part of the test, the surface was placed on the opposite side of the jet so that the jet noise was free to reflect off the surface toward the microphones. Phased array, pressure sensitive paint, and far field acoustic data obtained during JSIT1 are presented. The phased array data illustrate how the jet noise is blocked by the shielding surface. It also shows that the low frequency scrubbing noise generated when the surface is impacted by the jet comes predominantly from the surface trailing edge. The far field data show the trailing edge noise to be a dipole source. The pressure sensitive paint data show how the pressure distribution on the surface varies as the surface is traversed toward jet.



## Overview of the Jet / Surface Interaction Test (JSIT1)

Gary Podboy

Cliff Brown

Tim Bencic

Support Provided by the Subsonic Fixed Wing Program



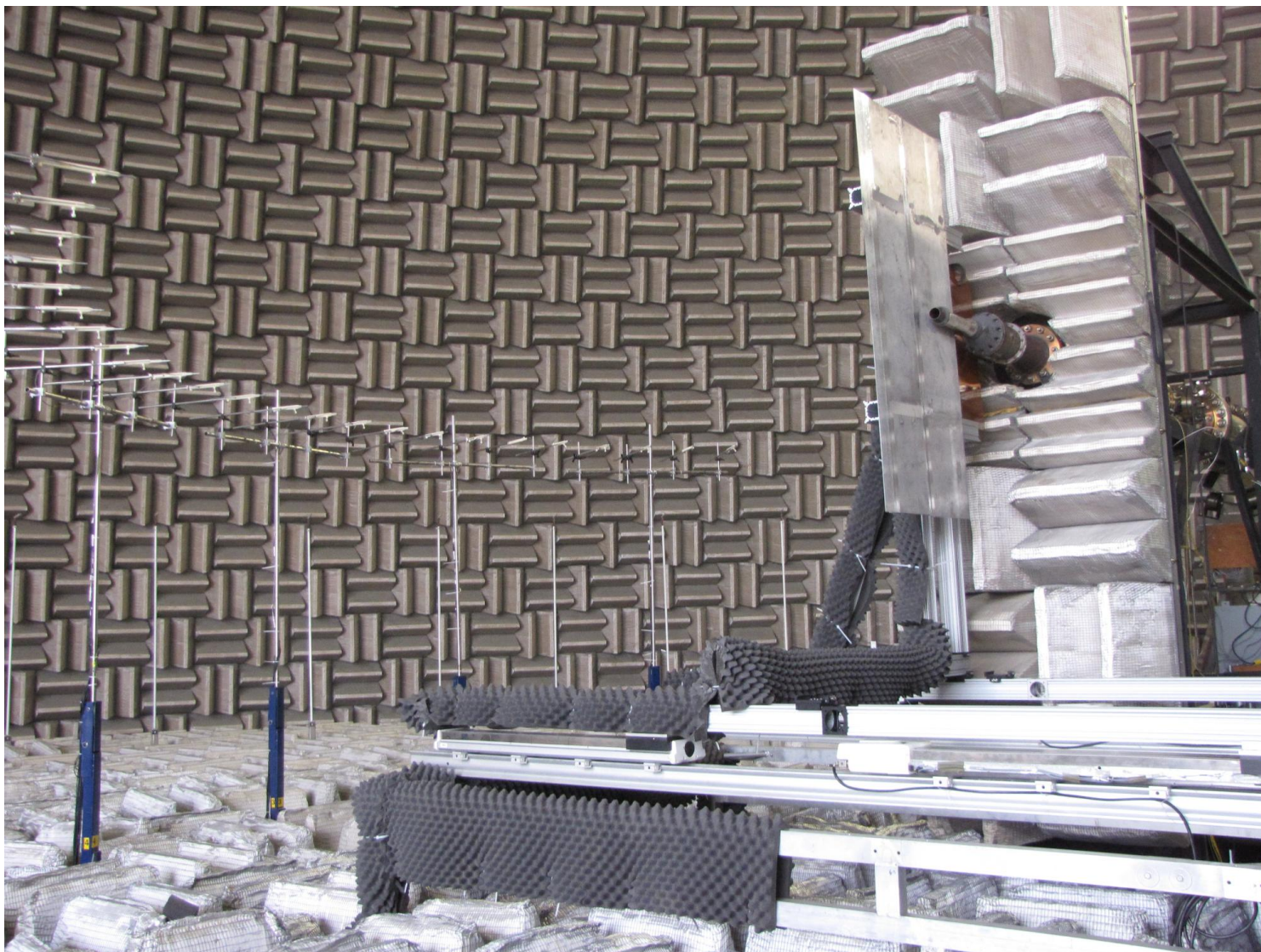
# Purpose of JSIT1

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Parametric study to expand the database available regarding how and where a planar surface can 1) shield and/or 2) enhance jet noise



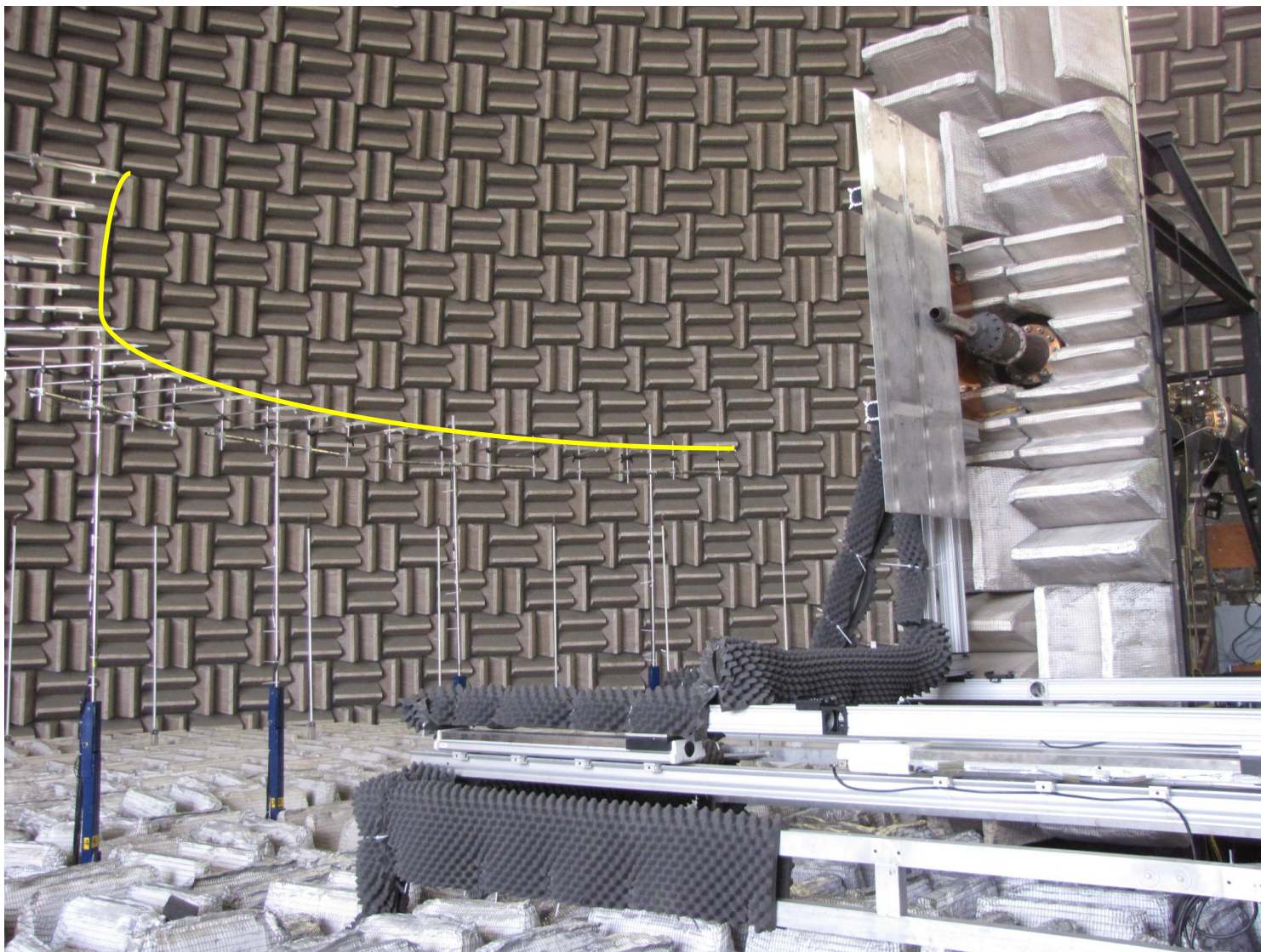
# Shielding Surface







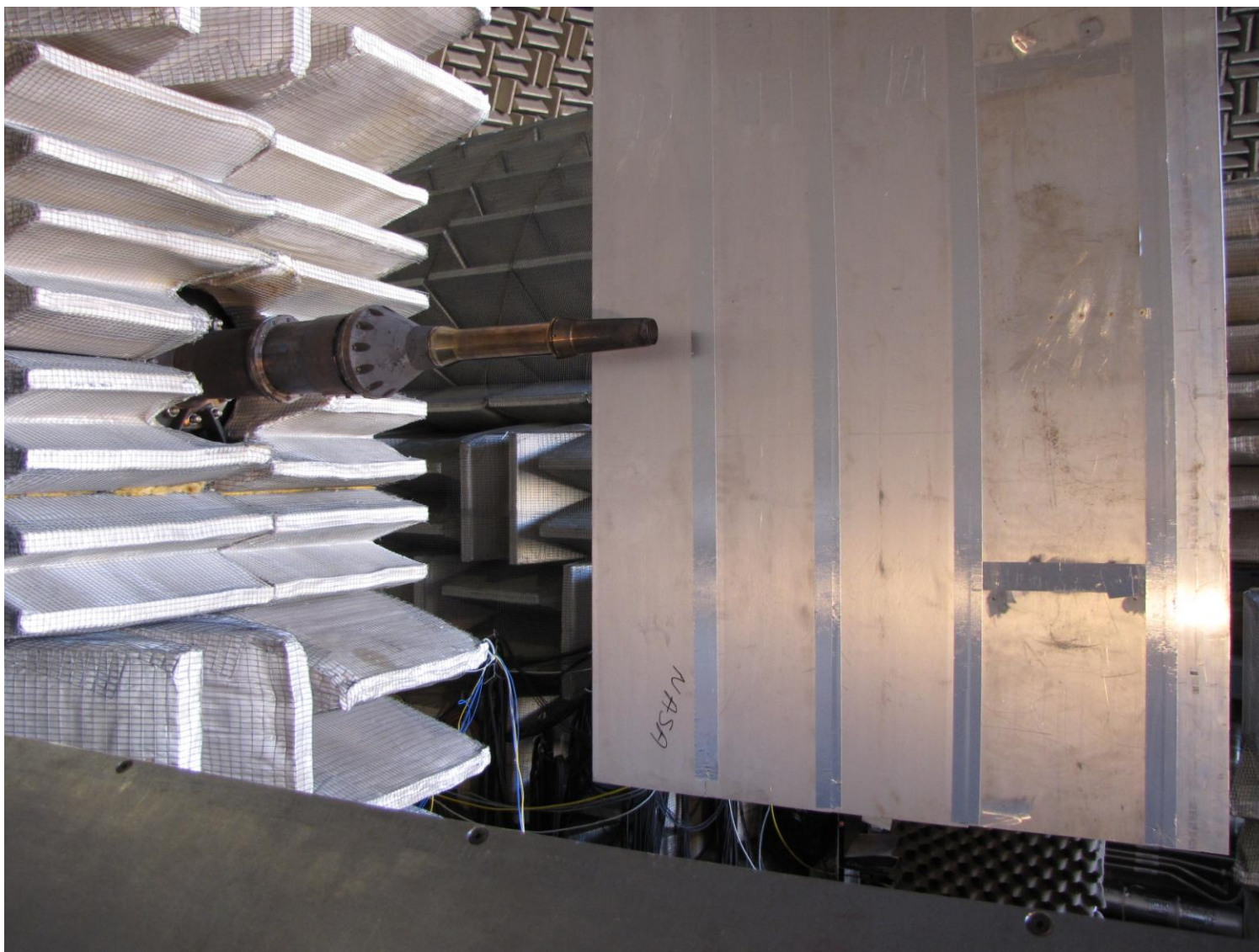
# Shielding Surface







# Reflecting Surface





# Parameters

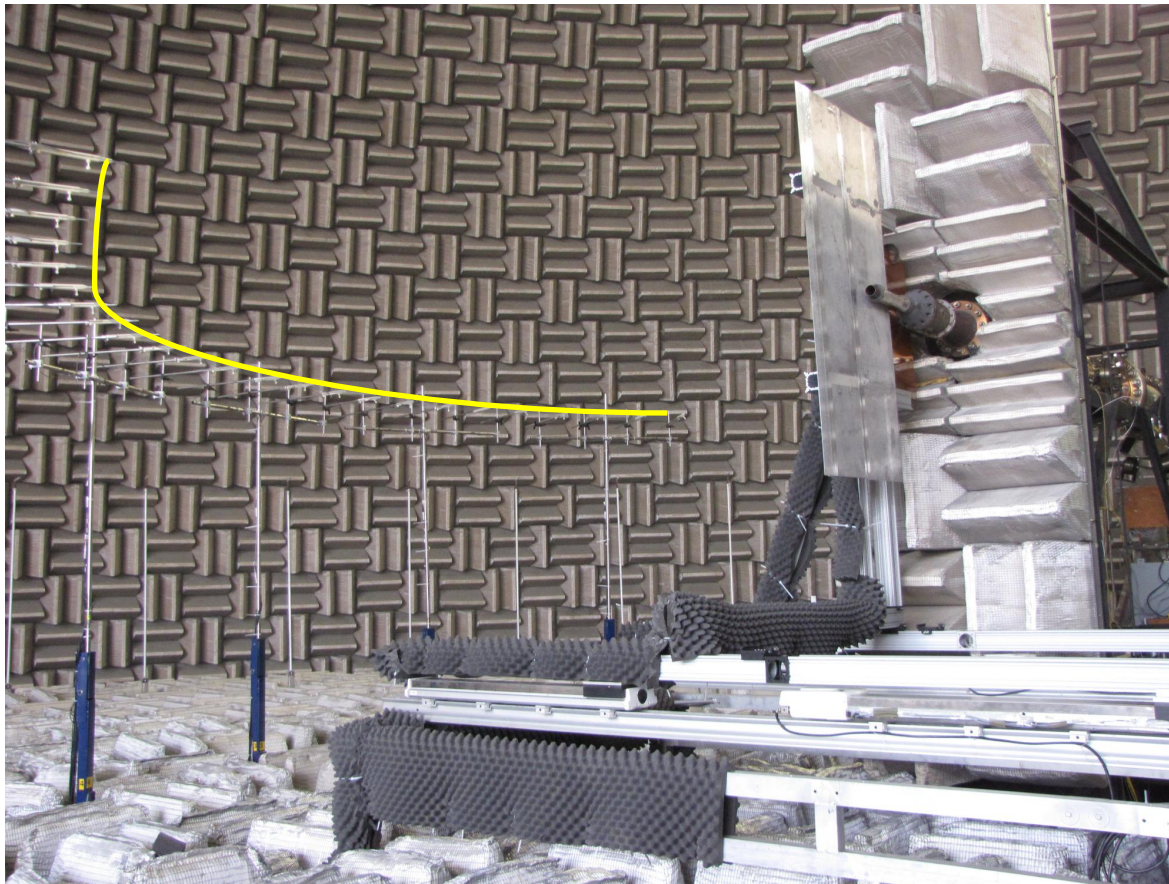
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- 1) Axial Dimension of Surface
- 2) Radial Location of Surface
- 3) Jet Operating Condition



# 4 Types of Data Acquired

- 1) Far field
- 2) Unsteady Surface Pressure
- 3) Phased Array
- 4) Pressure Sensitive Paint

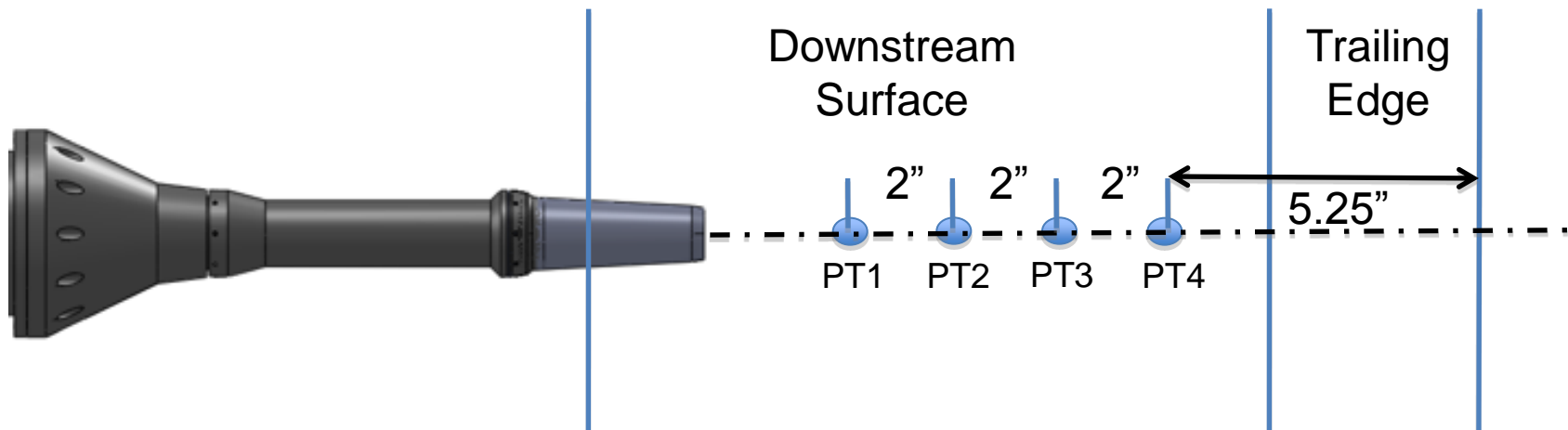
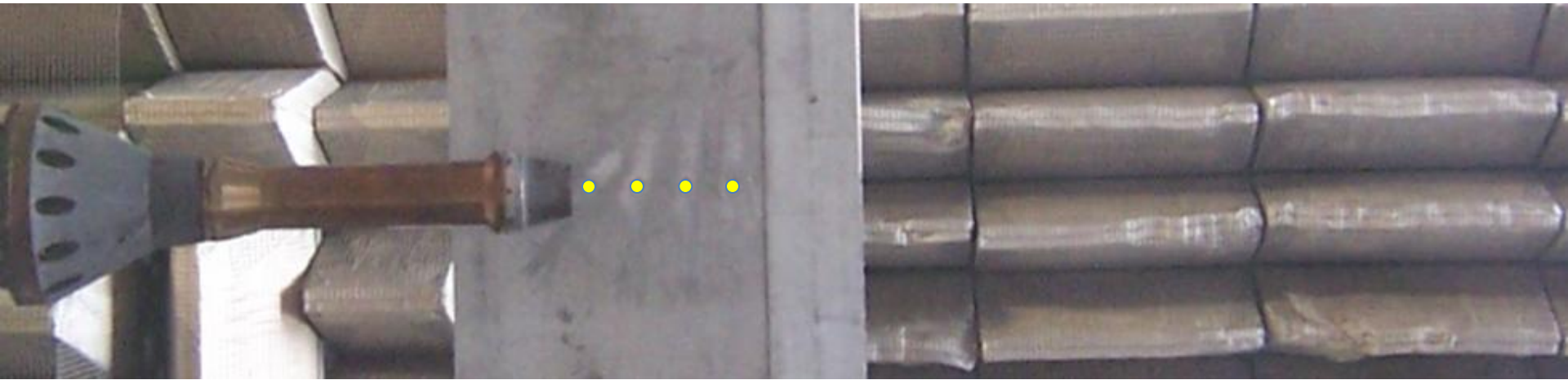






# 4 Types of Data Acquired

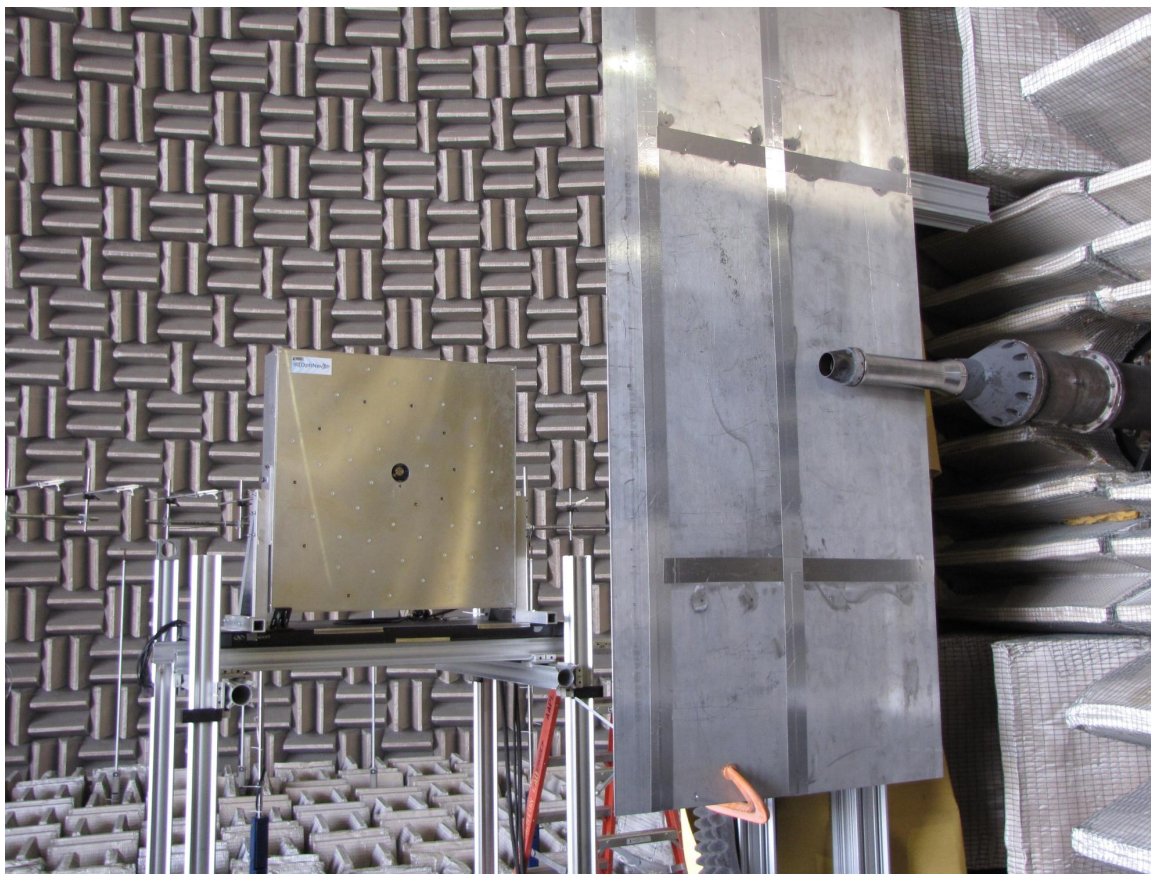
- 1) Far field
- 2) Unsteady Surface Pressure
- 3) Phased Array
- 4) Pressure Sensitive Paint





# 4 Types of Data Acquired

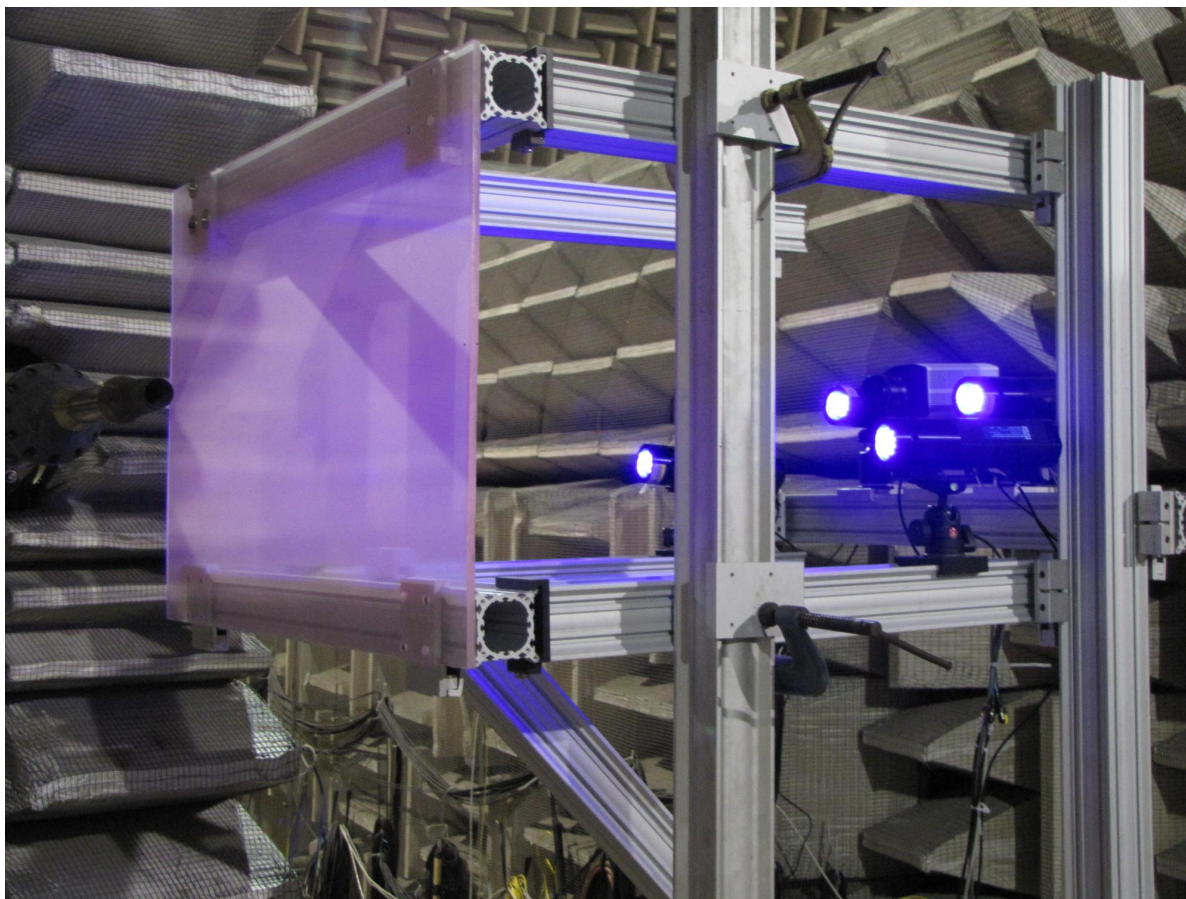
- 1) Far field
- 2) Unsteady Surface Pressure
- 3) **Phased Array**
- 4) Pressure Sensitive Paint





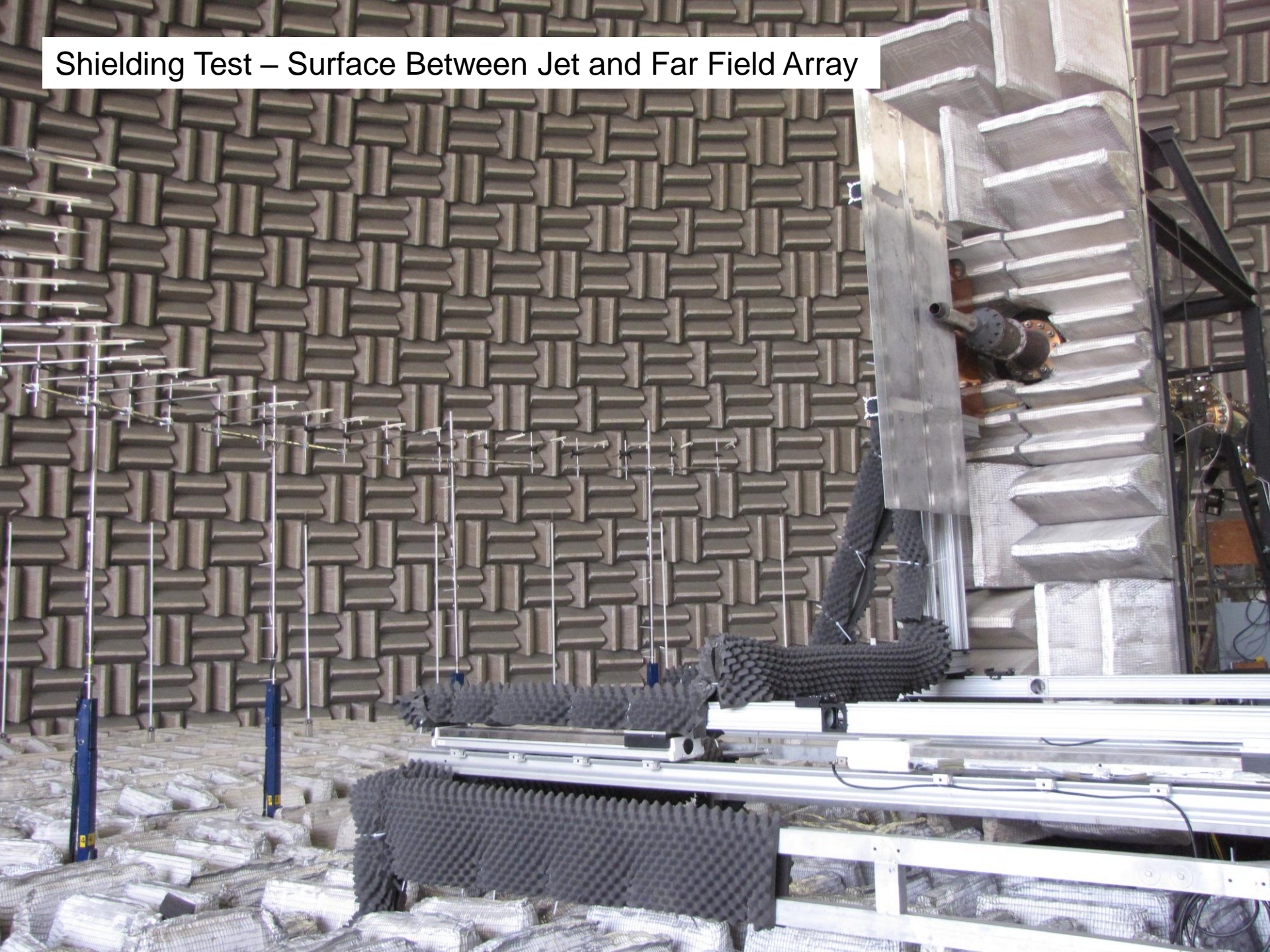
# 4 Types of Data Acquired

- 1) Far field
- 2) Unsteady Surface Pressure
- 3) Phased Array
- 4) Pressure Sensitive Paint



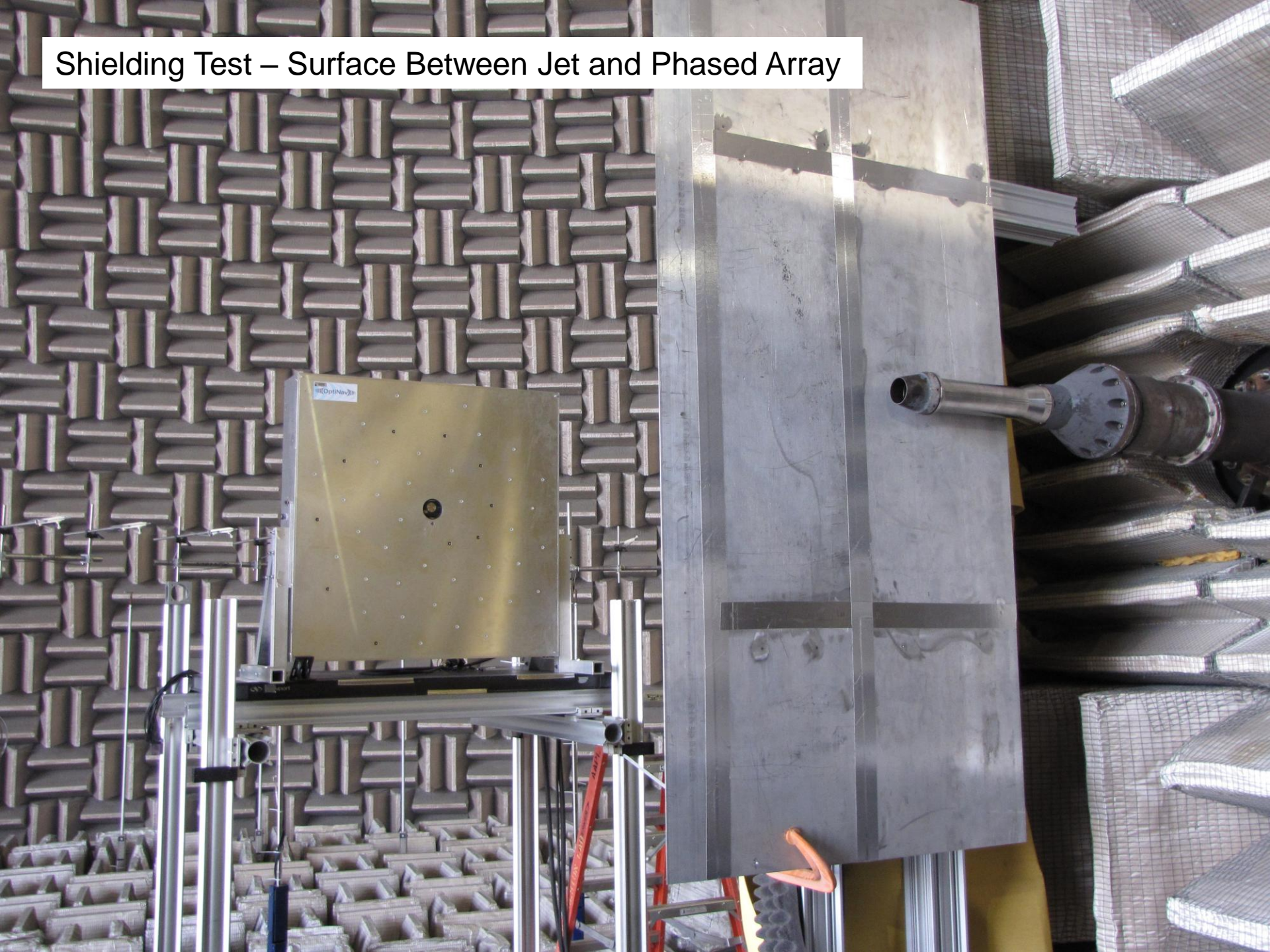


# Shielding Test – Surface Between Jet and Far Field Array



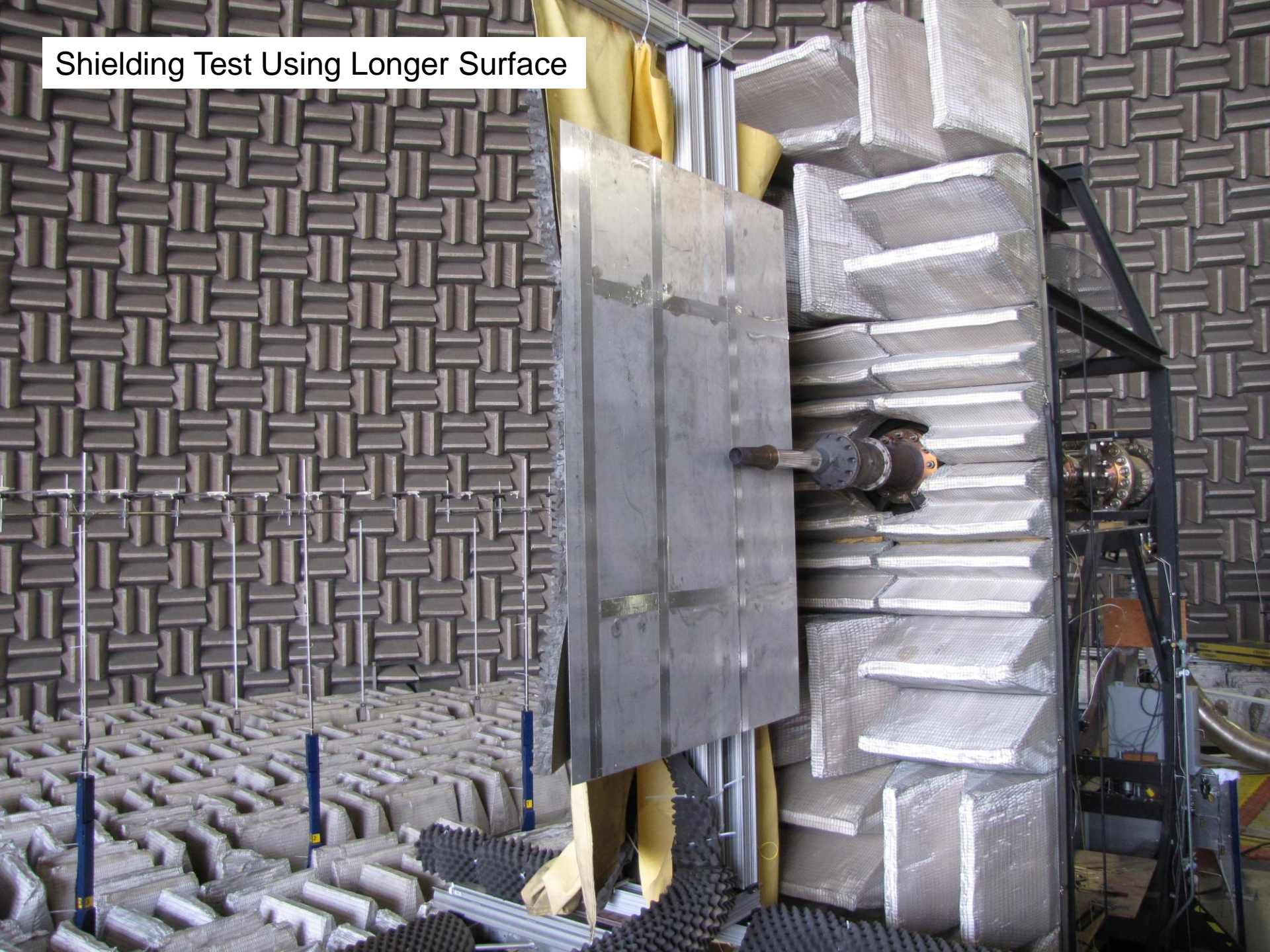


# Shielding Test – Surface Between Jet and Phased Array





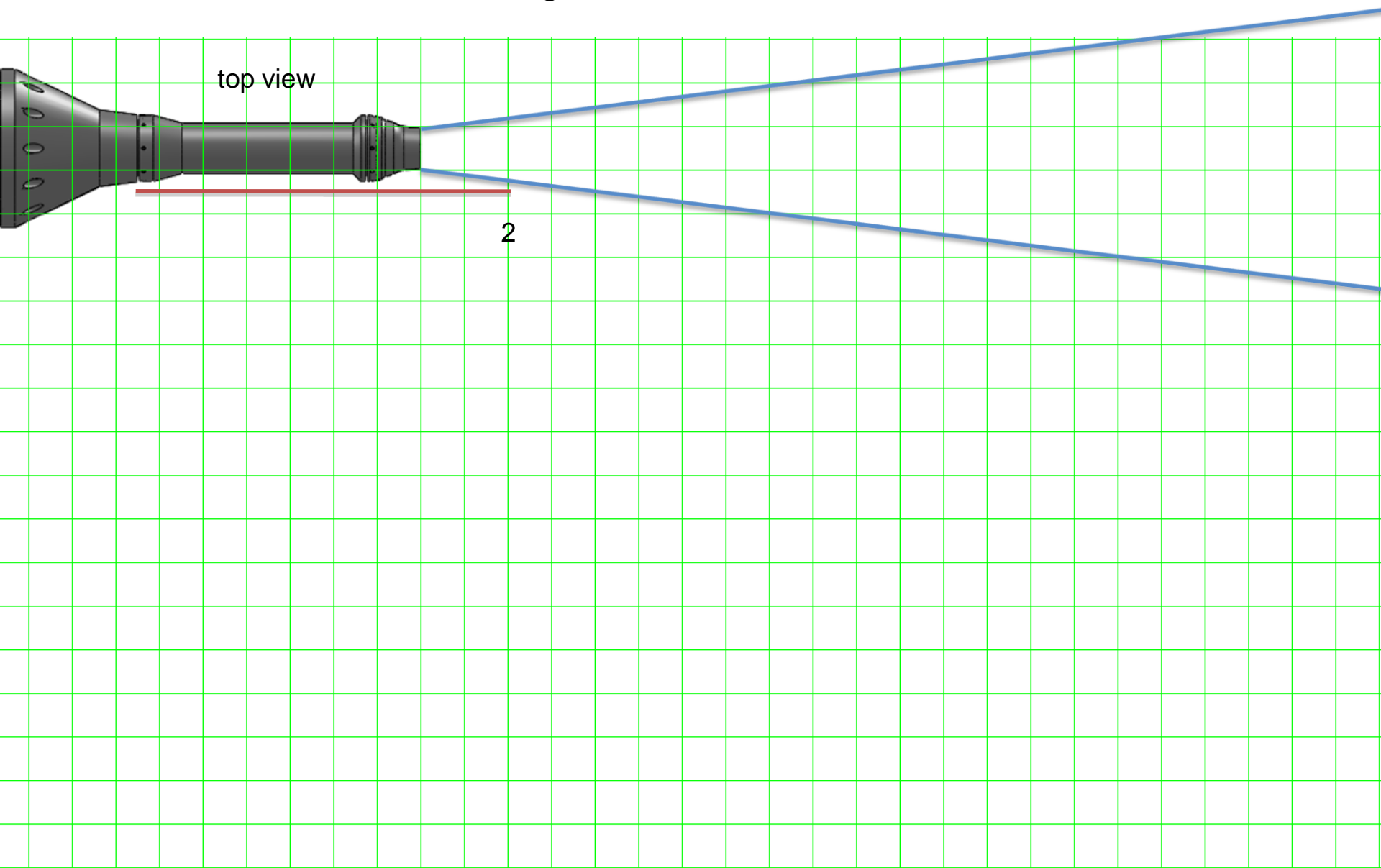
# Shielding Test Using Longer Surface





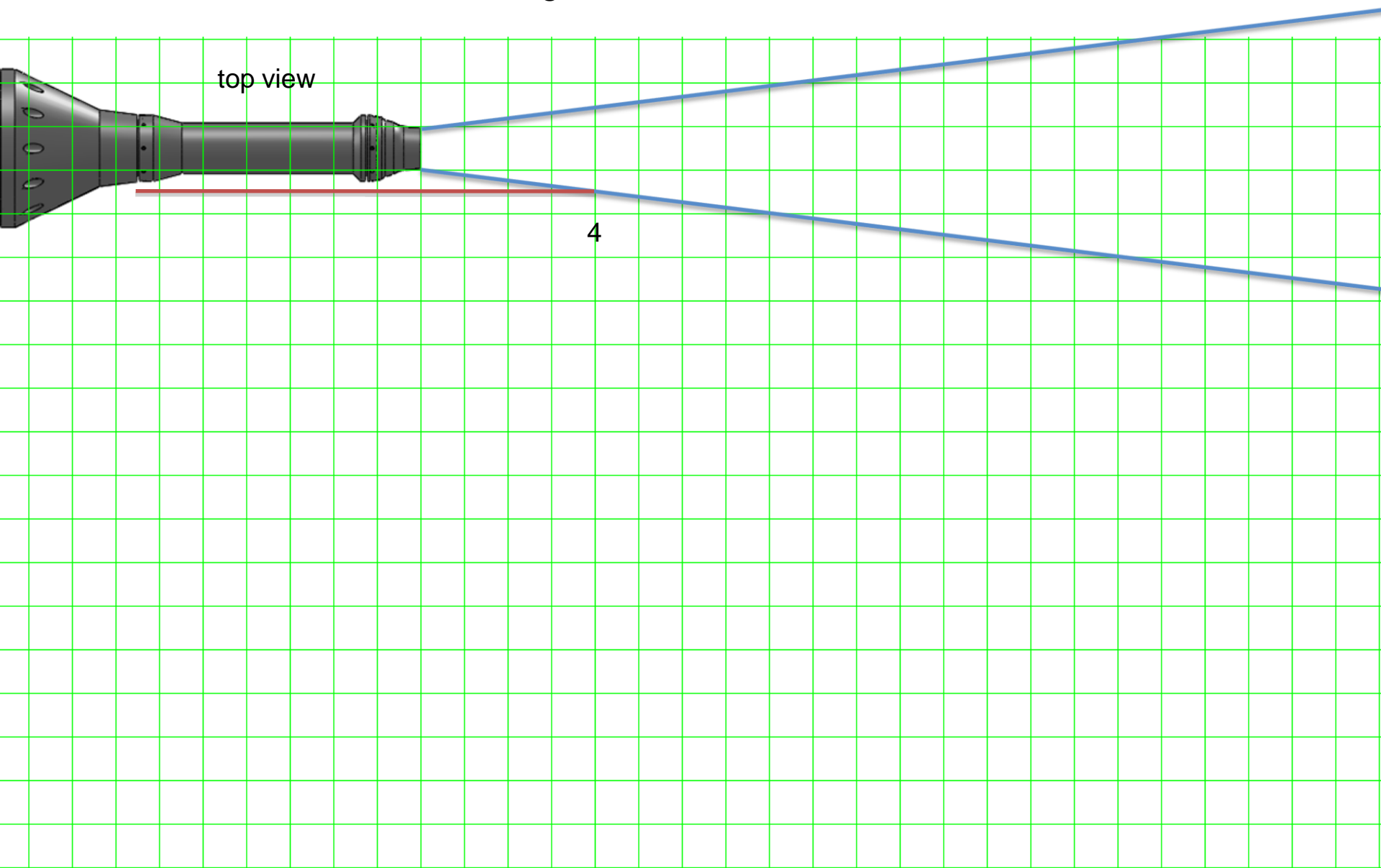
Baseline Round Convergent Nozzle, smc000

Shield TE @ 2 Diams



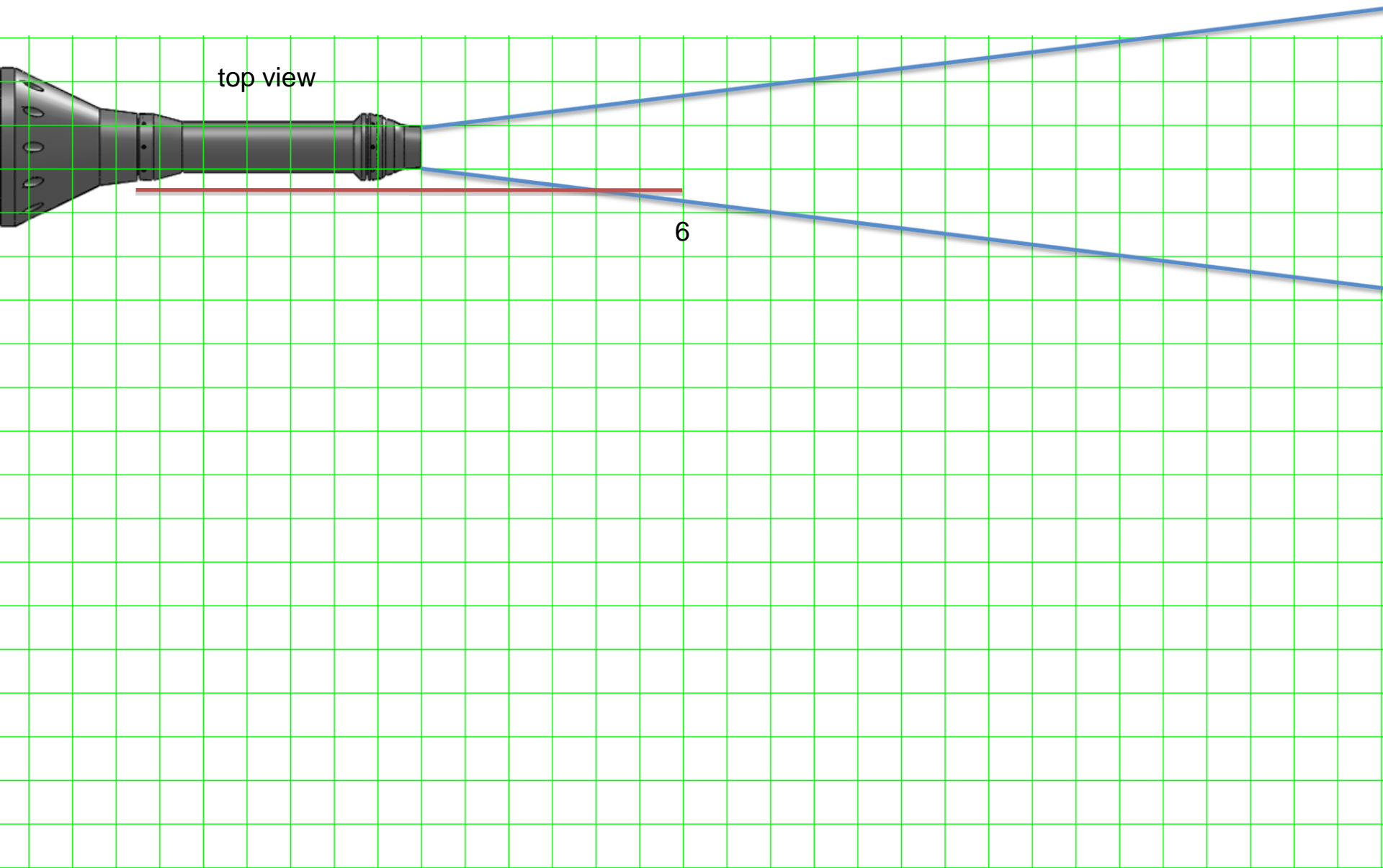
Baseline Round Convergent Nozzle, smc000

Shield TE @ 4 Diams



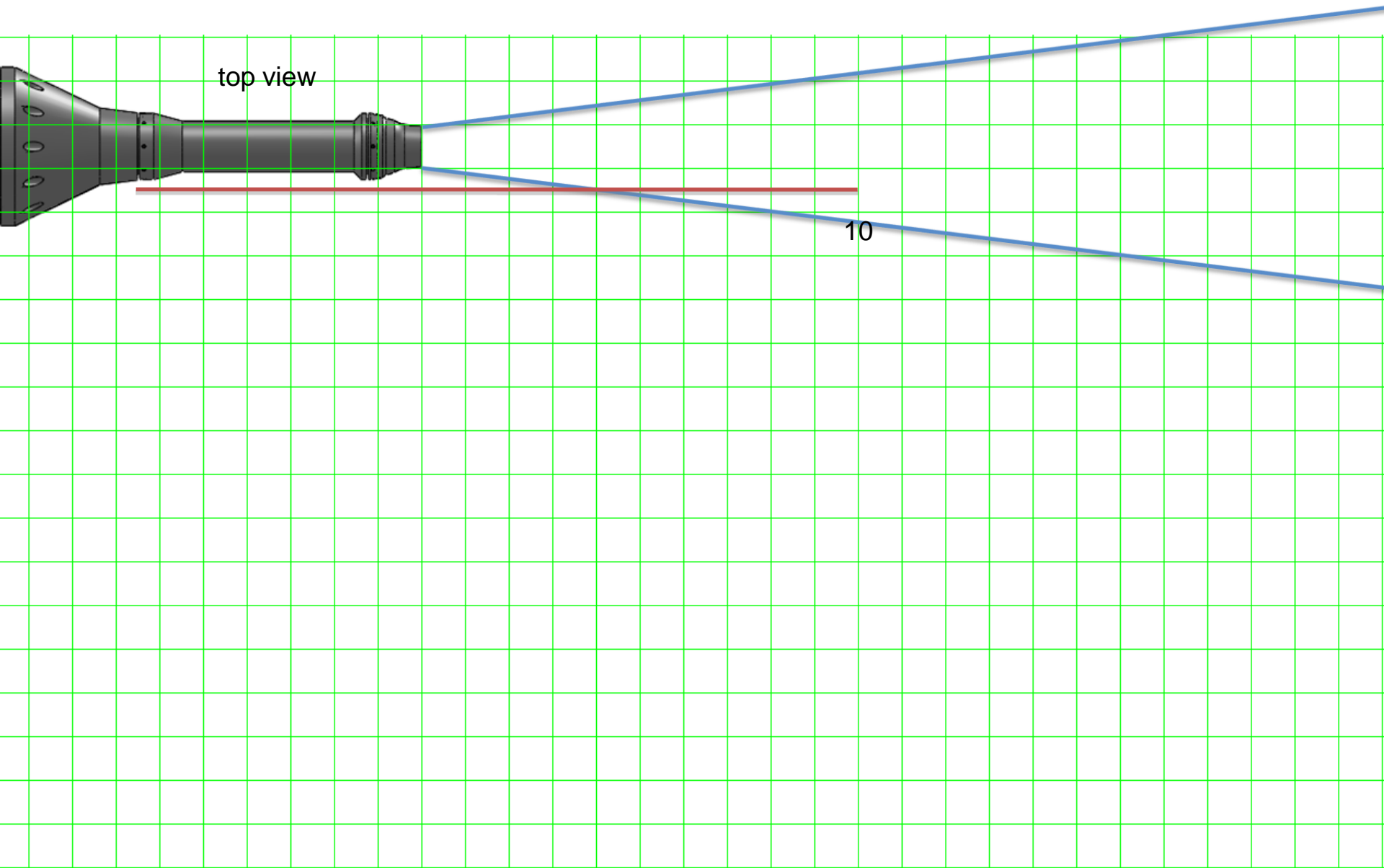
Baseline Round Convergent Nozzle, smc000

Shield TE @ 6 Diams

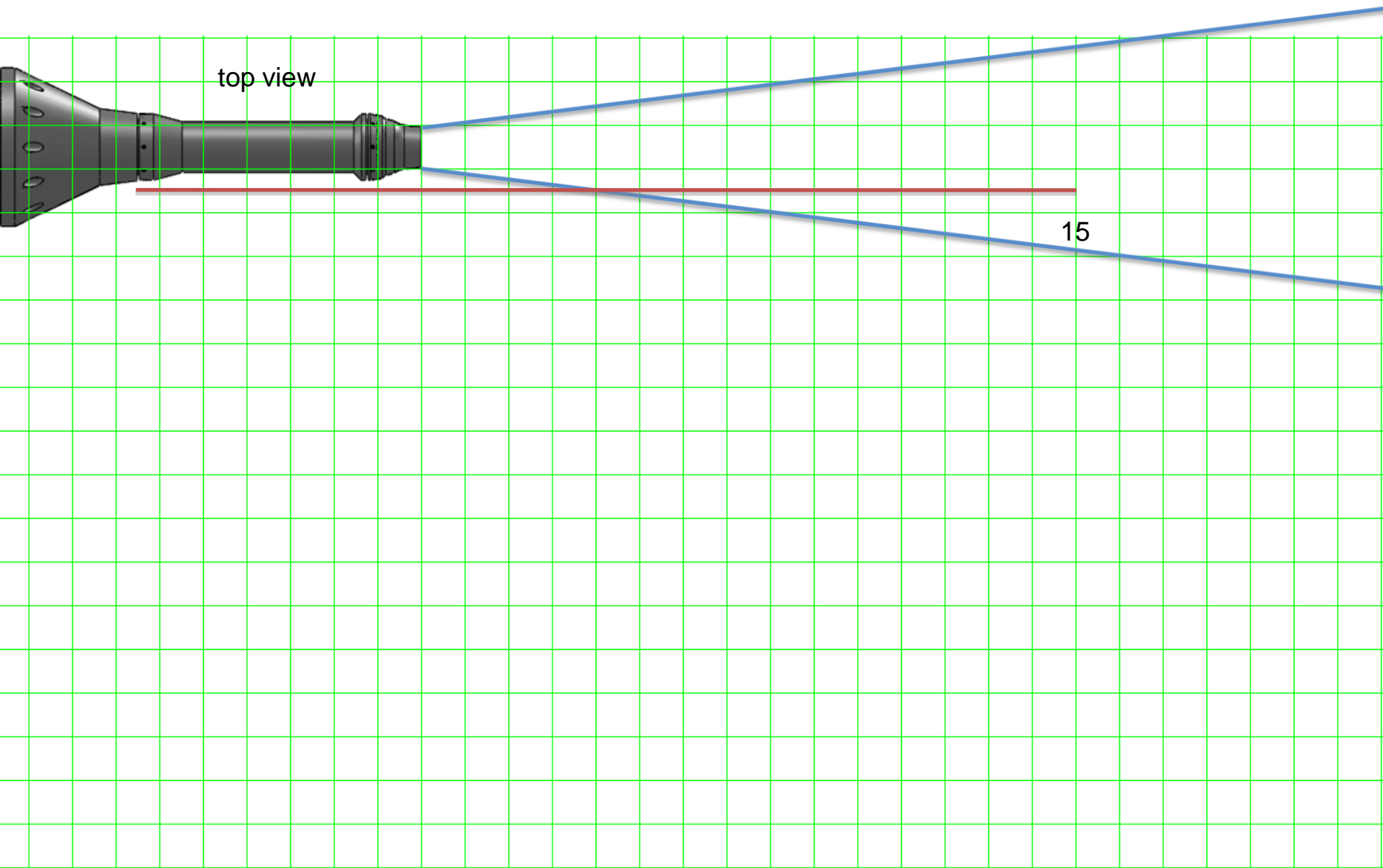




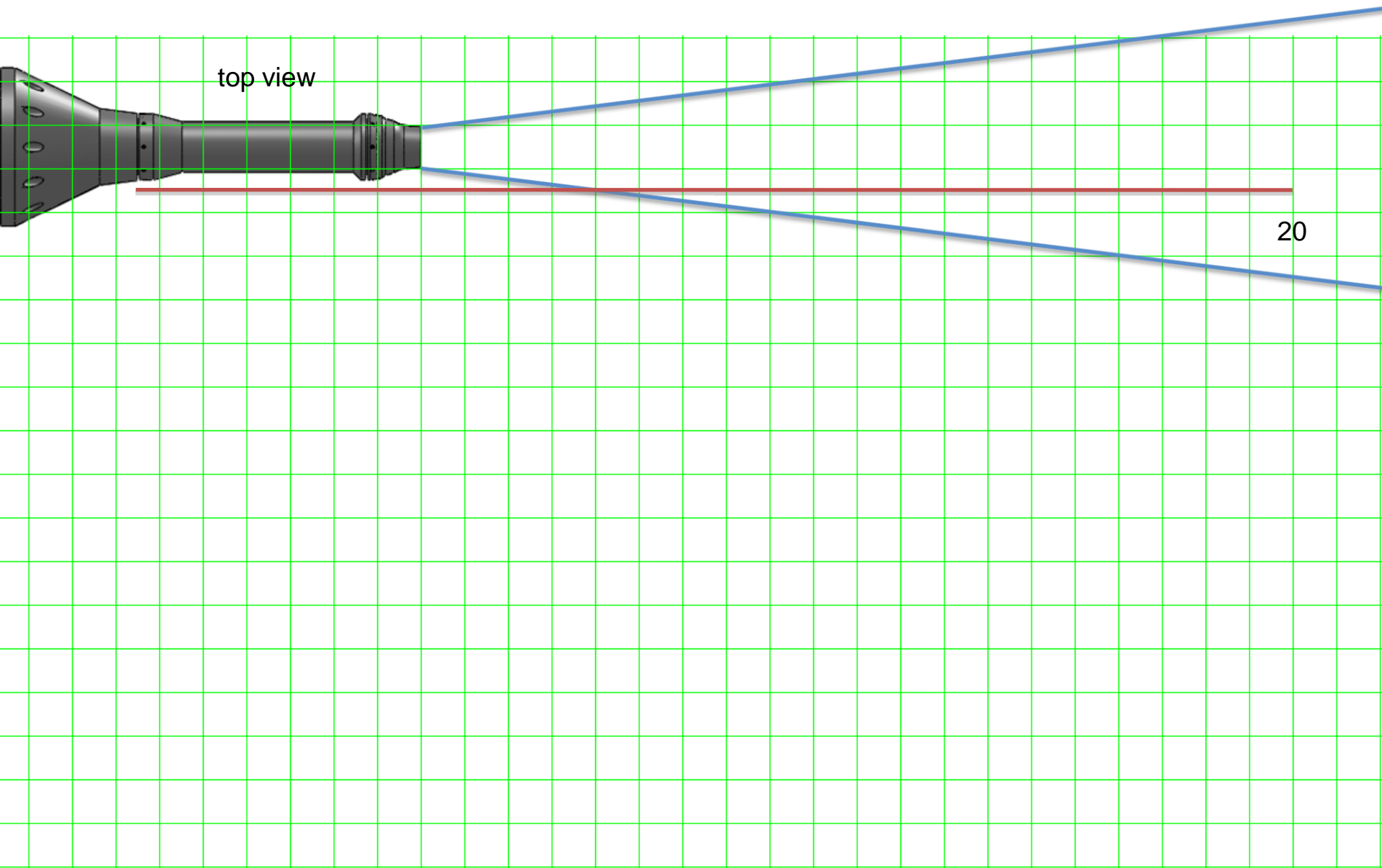
# Baseline Round Convergent Nozzle, smc000    Shield TE @ 10 Diams



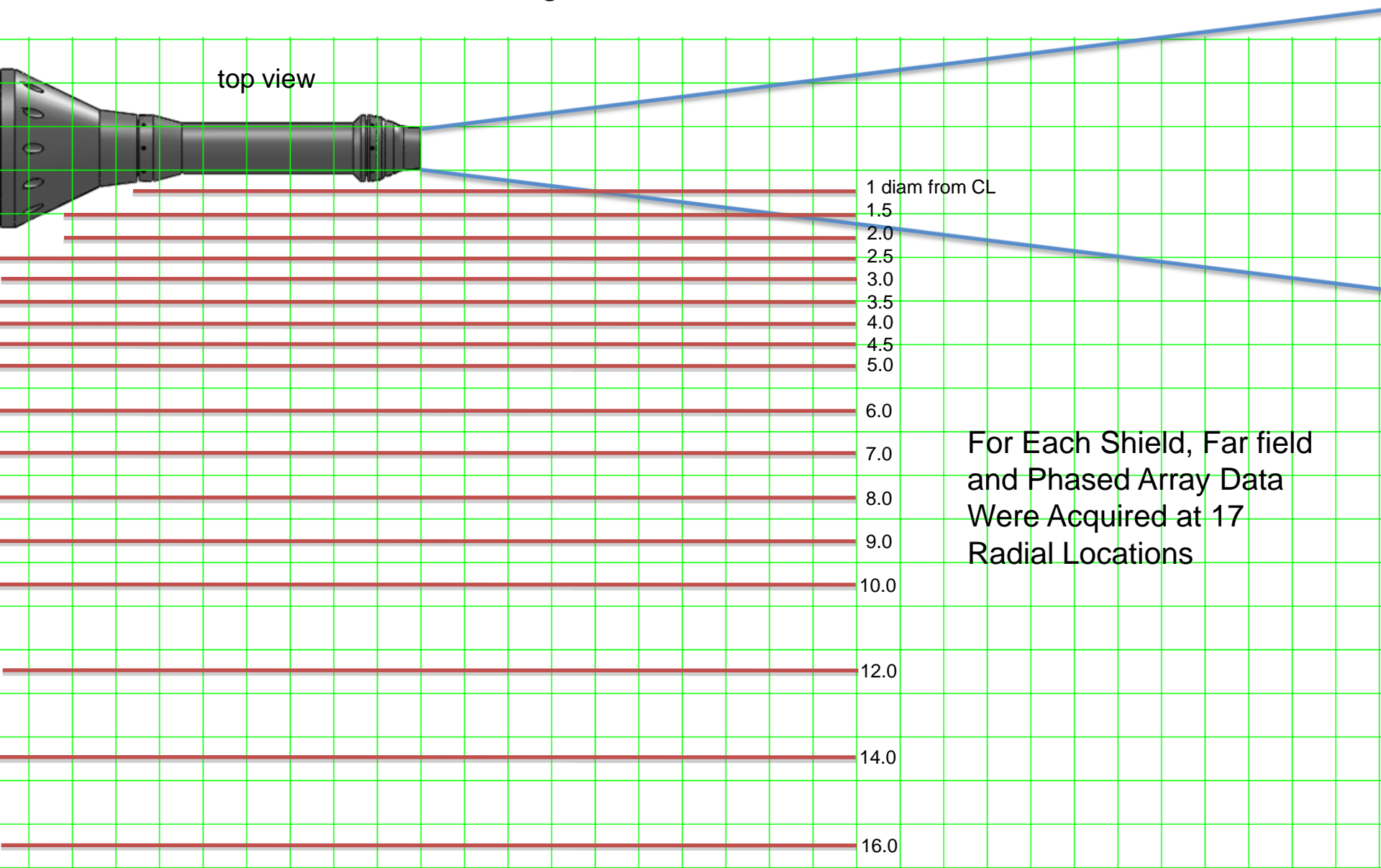
# Baseline Round Convergent Nozzle, smc000 Shield TE @ 15 Diams



# Baseline Round Convergent Nozzle, smc000    Shield TE @ 20 Diams



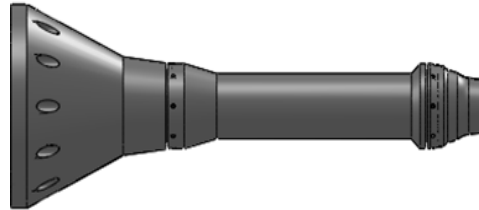
# Baseline Round Convergent Nozzle, smc000 Shield TE @ 10 Diams





# Shielding Test

## Baseline Round Convergent Nozzle, smc000

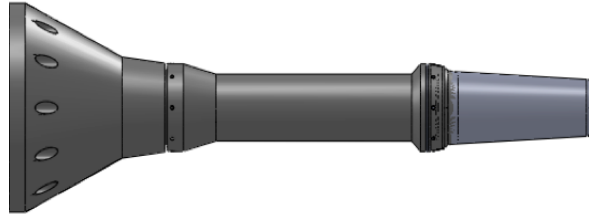


6 Axial X 17 Radial X 5 Set Points = 510

Setpoint	NPR	NTR	Ma	Mj
	$P_{j\_total}/P_a$	$T_{j\_static}/T_a$	$V_j/c_a$	$V_j/c_{local}$
3	1.197	0.95	0.5	0.51
7	1.86	0.835	0.9	0.98
27	1.36	1.764	0.9	0.68
46	1.227	2.7	0.9	0.55
9010	3.182	0.74	1.18	1.40

# Shielding Test

## Convergent Divergent Nozzle, smc016

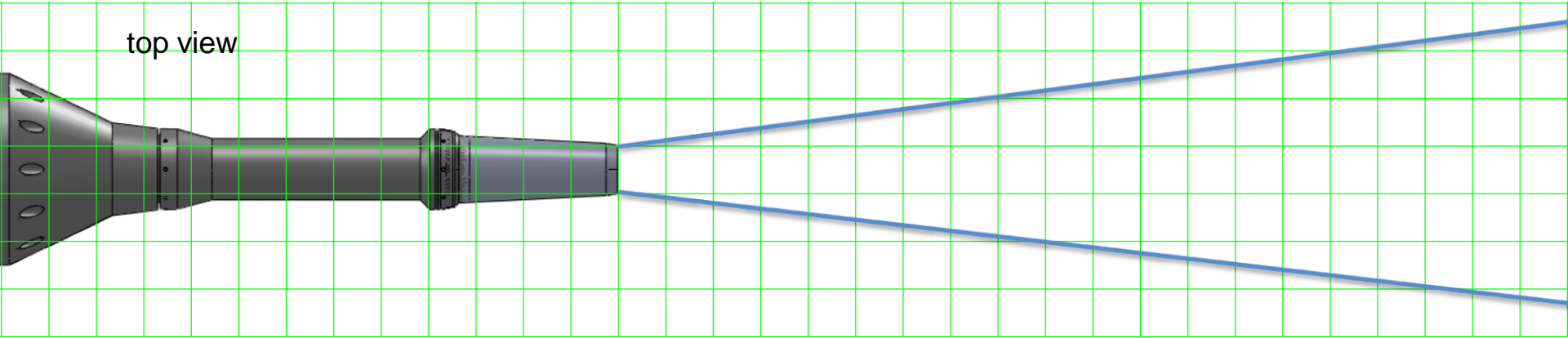


6 Axial X 17 Radial X 3 Set Points = 306

Setpoint	NPR	NTR	Ma	Mj	
	$P_{j\_total}/P_a$	$T_{j\_static}/T_a$	$V_j/c_a$	$V_j/c_{local}$	
11606	2.748	0.761	1.128	1.29	Overexpanded
11610	3.670	0.706	1.31	1.5	Design
11617	4.324	0.671	1.41	1.61	Underexpanded

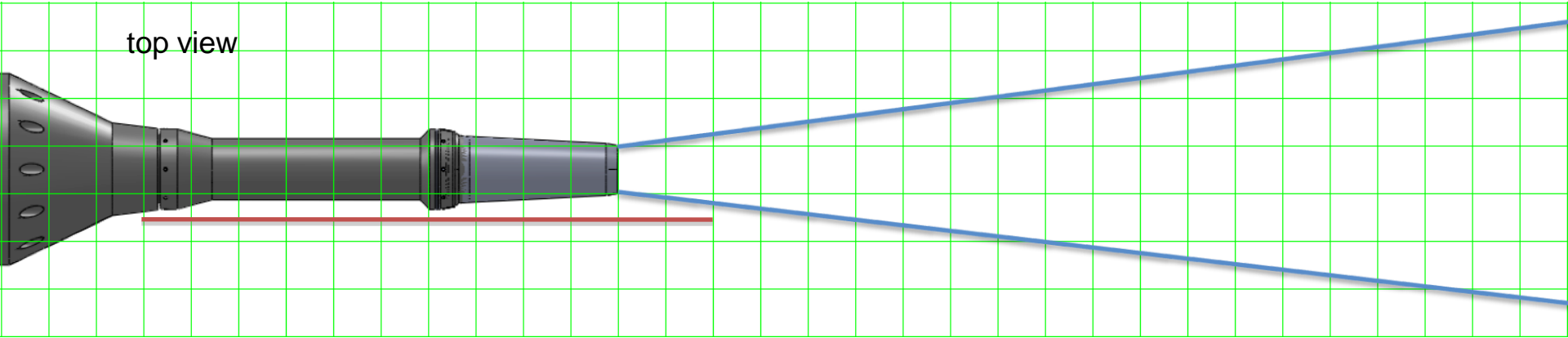
# No Shield, Convergent Divergent Nozzle

top view



# Shielding at 2 Diameters, Convergent Divergent Nozzle

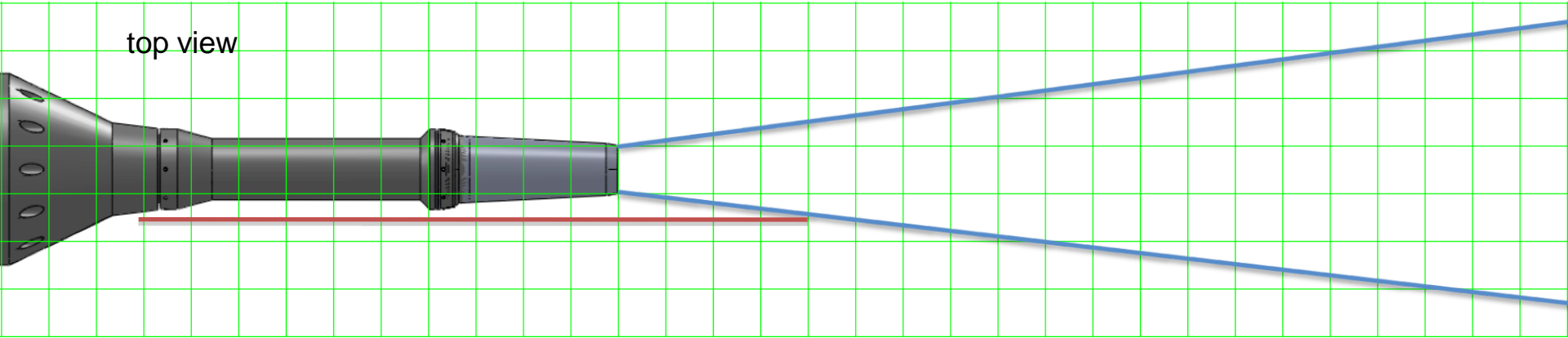
top view



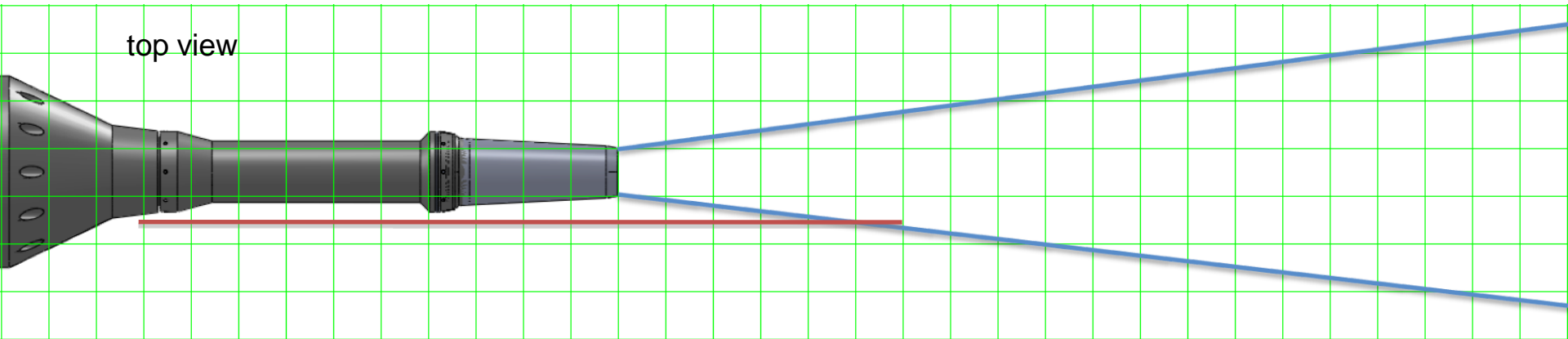


# Shielding at 4 Diameters, Convergent Divergent Nozzle

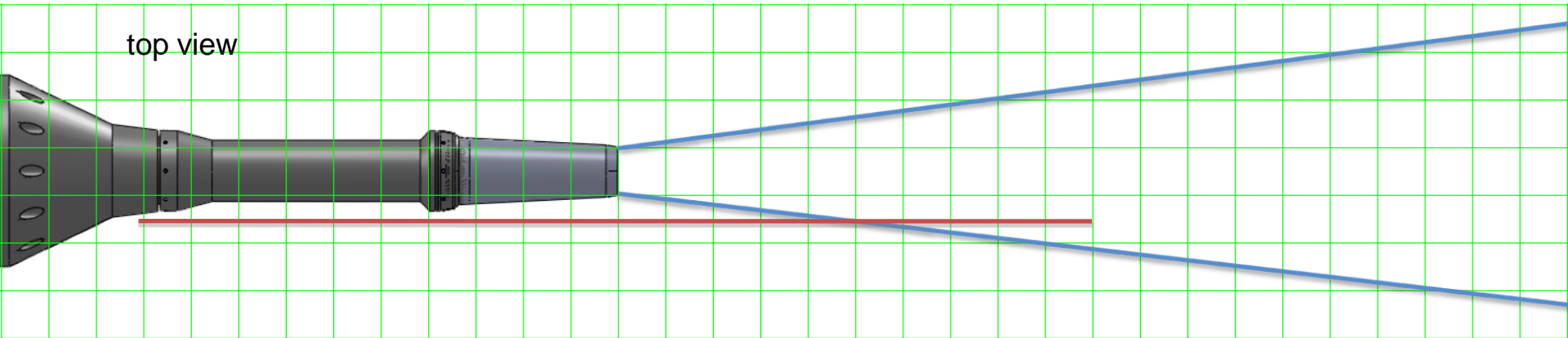
top view



# Shielding at 6 Diameters, Convergent Divergent Nozzle

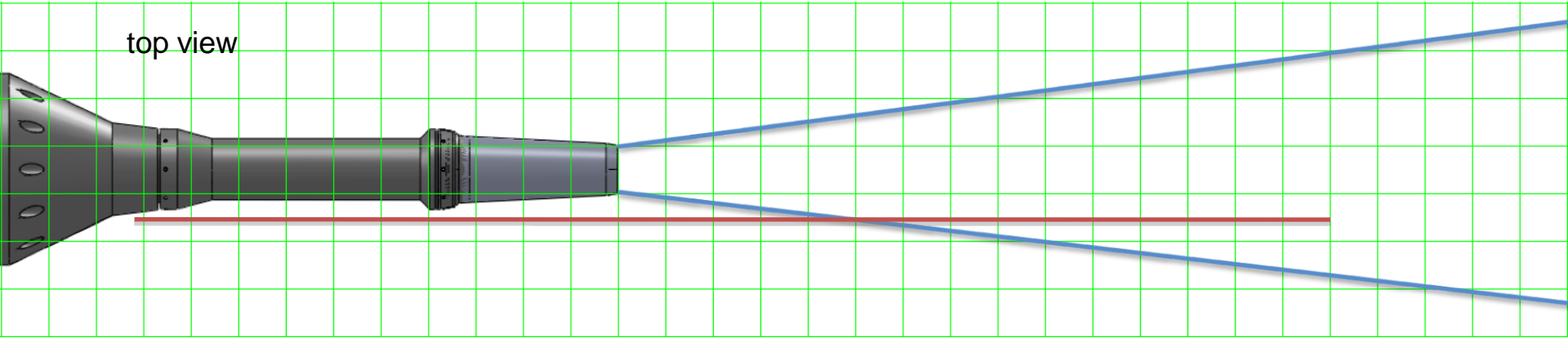


# Shielding at 10 Diameters, Convergent Divergent Nozzle



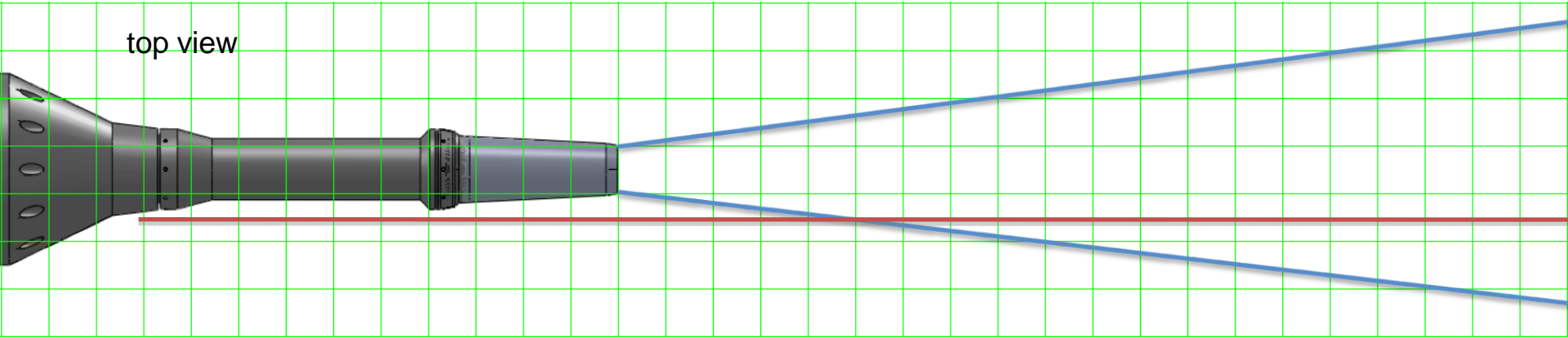
# Shielding at 15 Diameters, Convergent Divergent Nozzle

top view



# Shielding at 20 Diameters, Convergent Divergent Nozzle

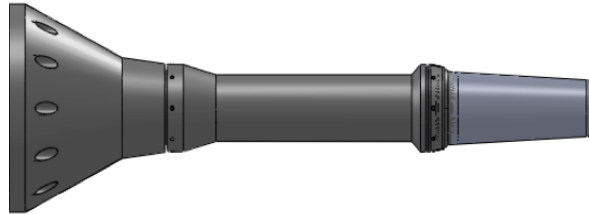
top view





## Shielding Test

### Convergent Divergent Nozzle, smc016

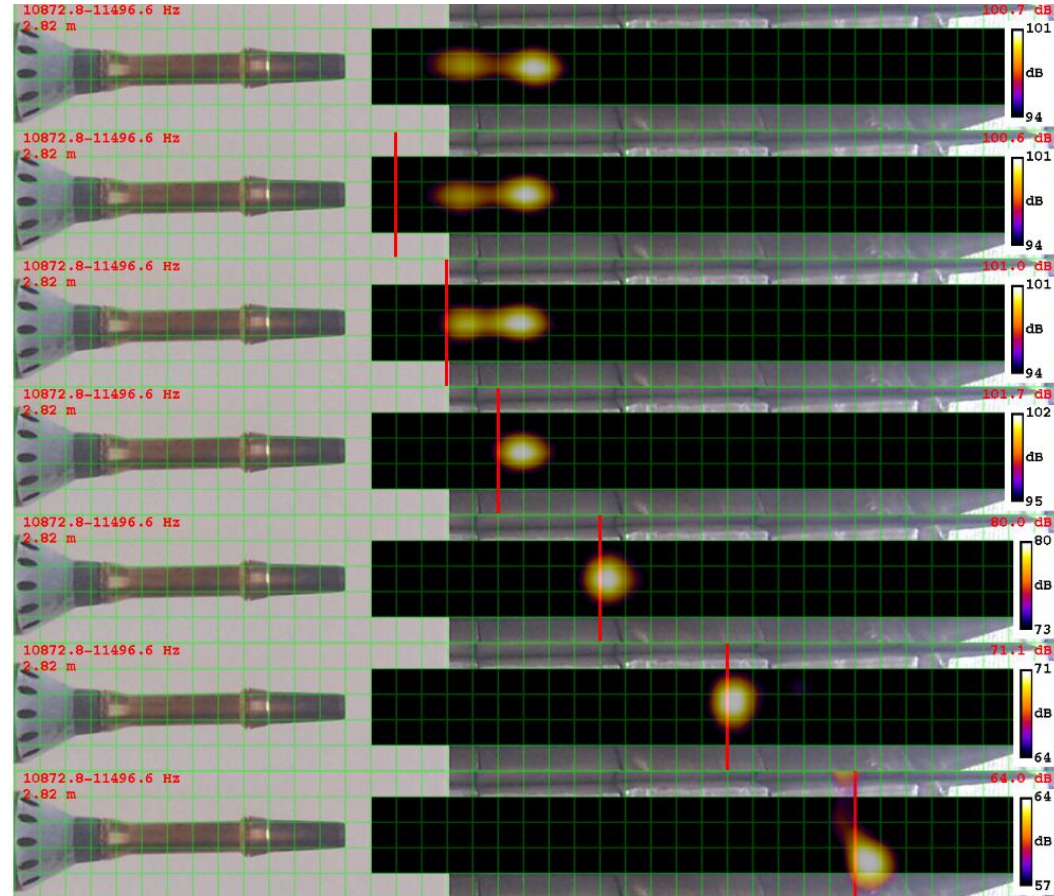
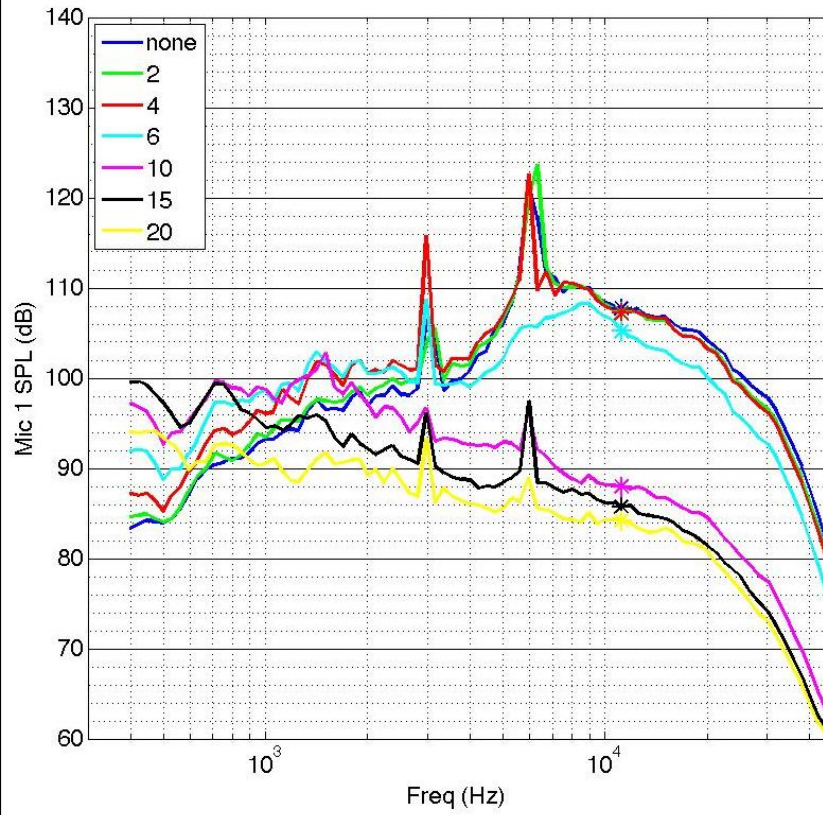


6 Axial X 17 Radial X 3 Set Points

Setpoint	NPR	NTR	Ma	Mj	
	$P_{j\_total}/P_a$	$T_{j\_static}/T_a$	$V_j/c_a$	$V_j/c_{local}$	
11606	2.748	0.761	1.128	1.29	Overexpanded
11610	3.670	0.706	1.31	1.5	Design
11617	4.324	0.671	1.41	1.61	Underexpanded

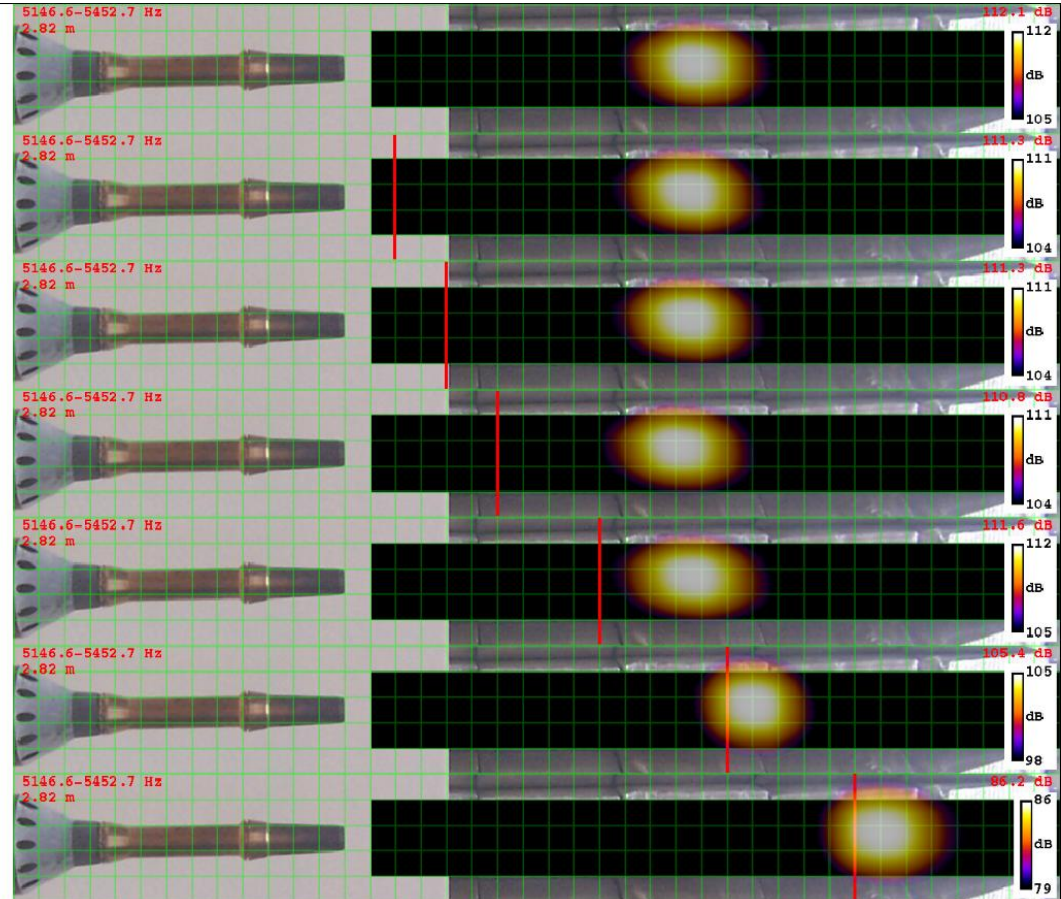
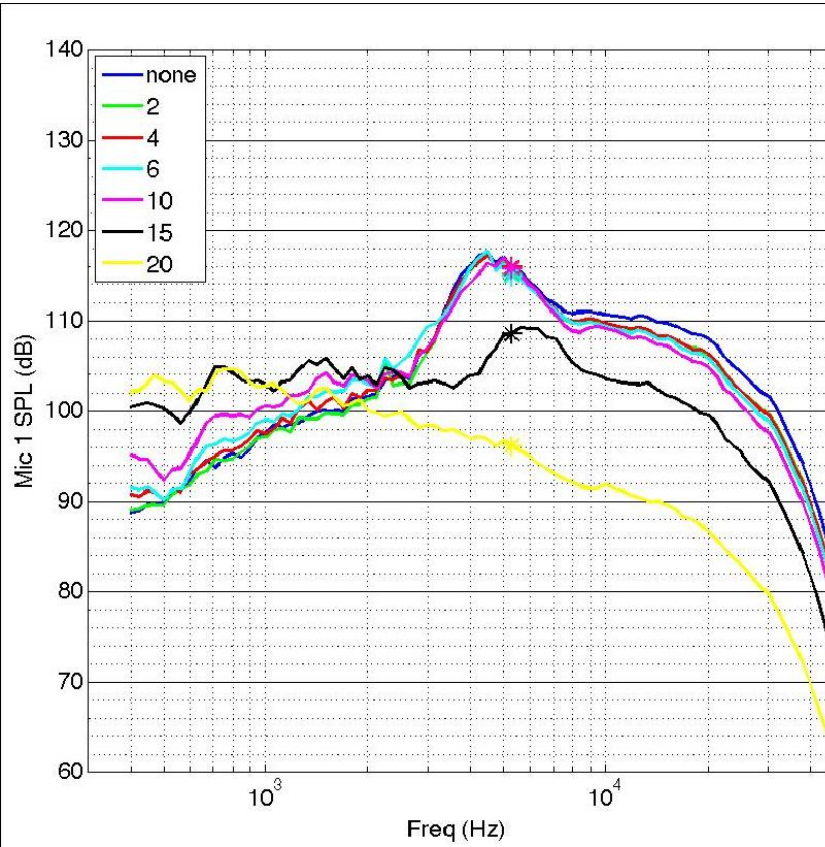
# Example Shielding Data

Setpoint	NPR Pj_total/Pa	NTR Tj_static/Ta	Ma Vj/ca	Mj Vj/c_local	
11606	2.748	0.761	1.128	1.29	Overexpanded



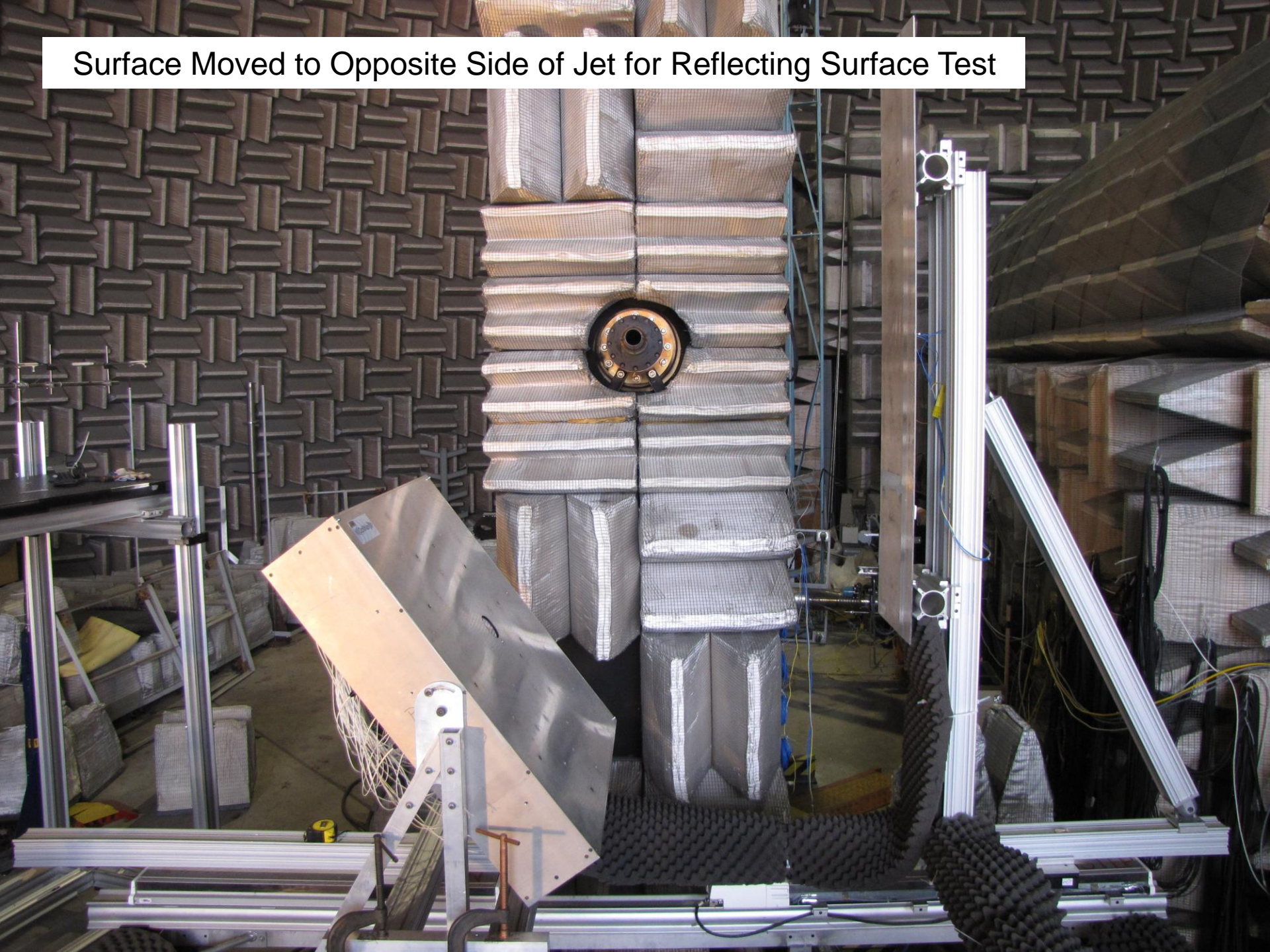
# Example Shielding Data

Setpoint	NPR Pj_total/Pa	NTR Tj_static/Ta	Ma Vj/ca	Mj Vj/c_local	
11617	4.324	0.671	1.41	1.61	Underexpanded



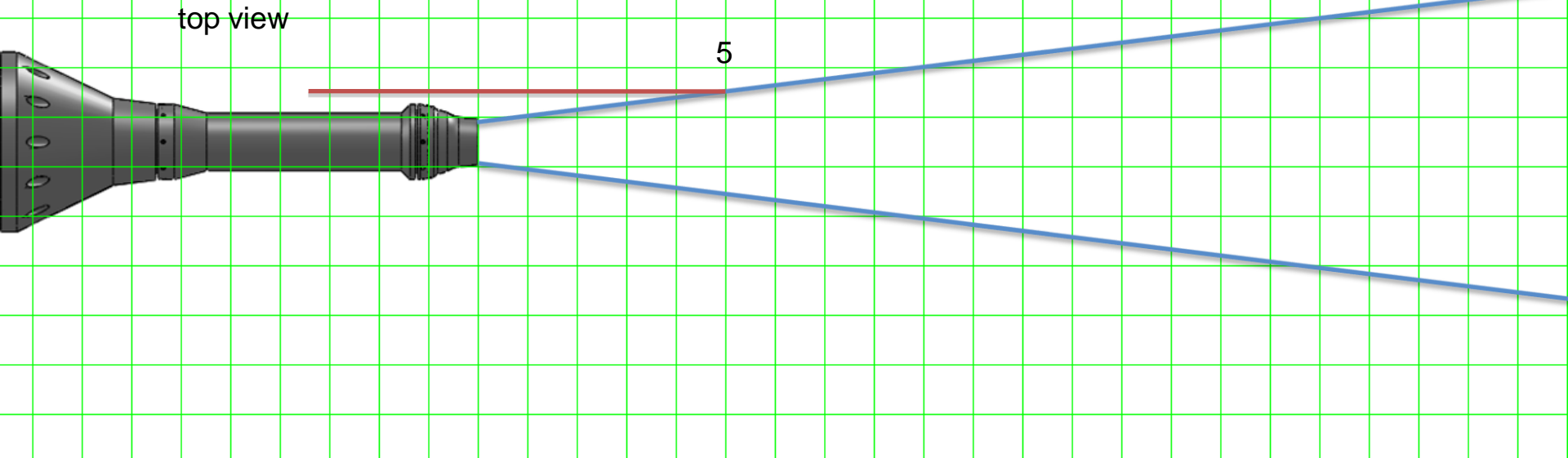


Surface Moved to Opposite Side of Jet for Reflecting Surface Test



Baseline Round Convergent Nozzle, smc000

Surface TE @ 5 Diams

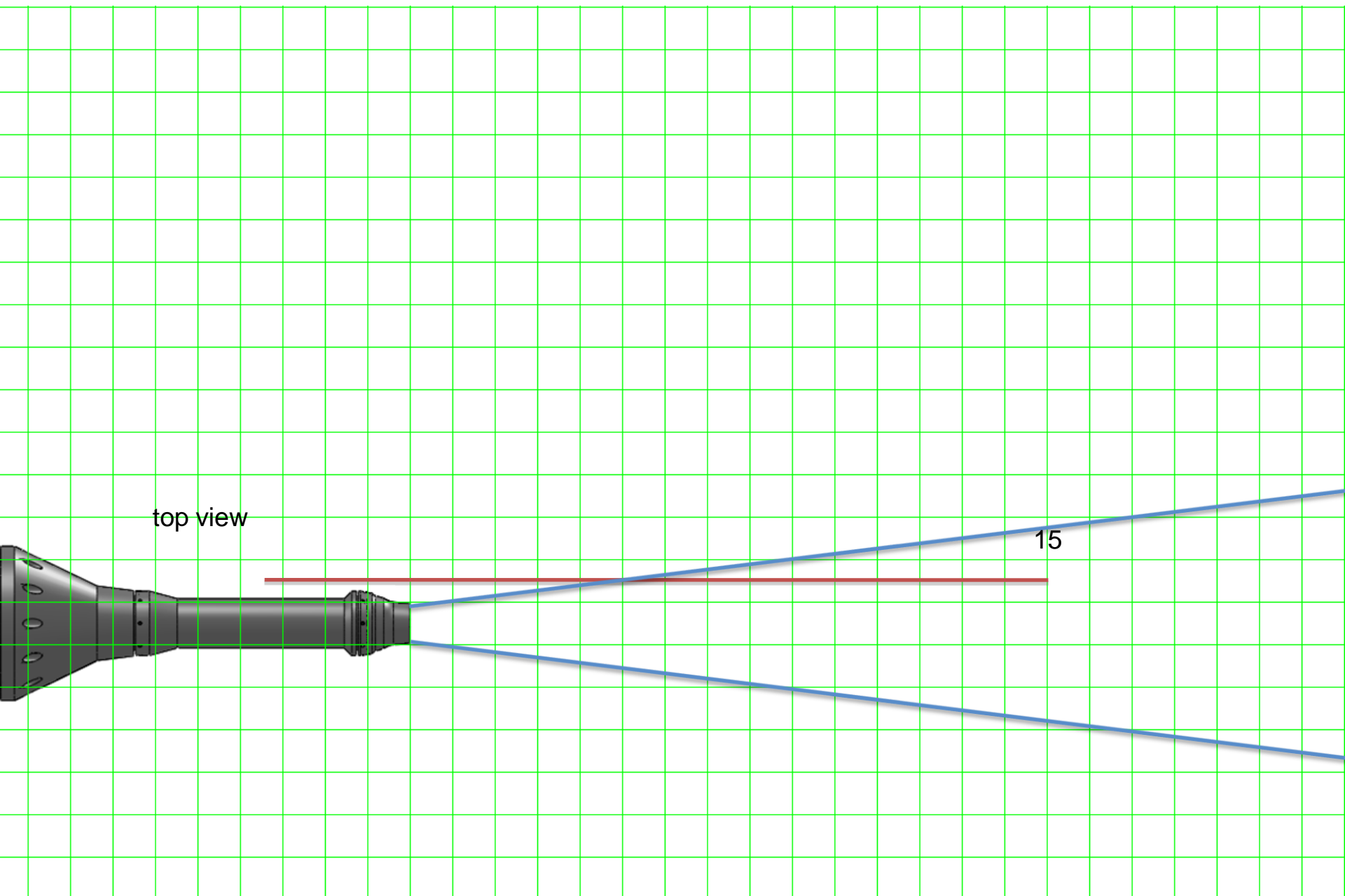


# Baseline Round Convergent Nozzle, smc000      Surface TE @ 10 Diams

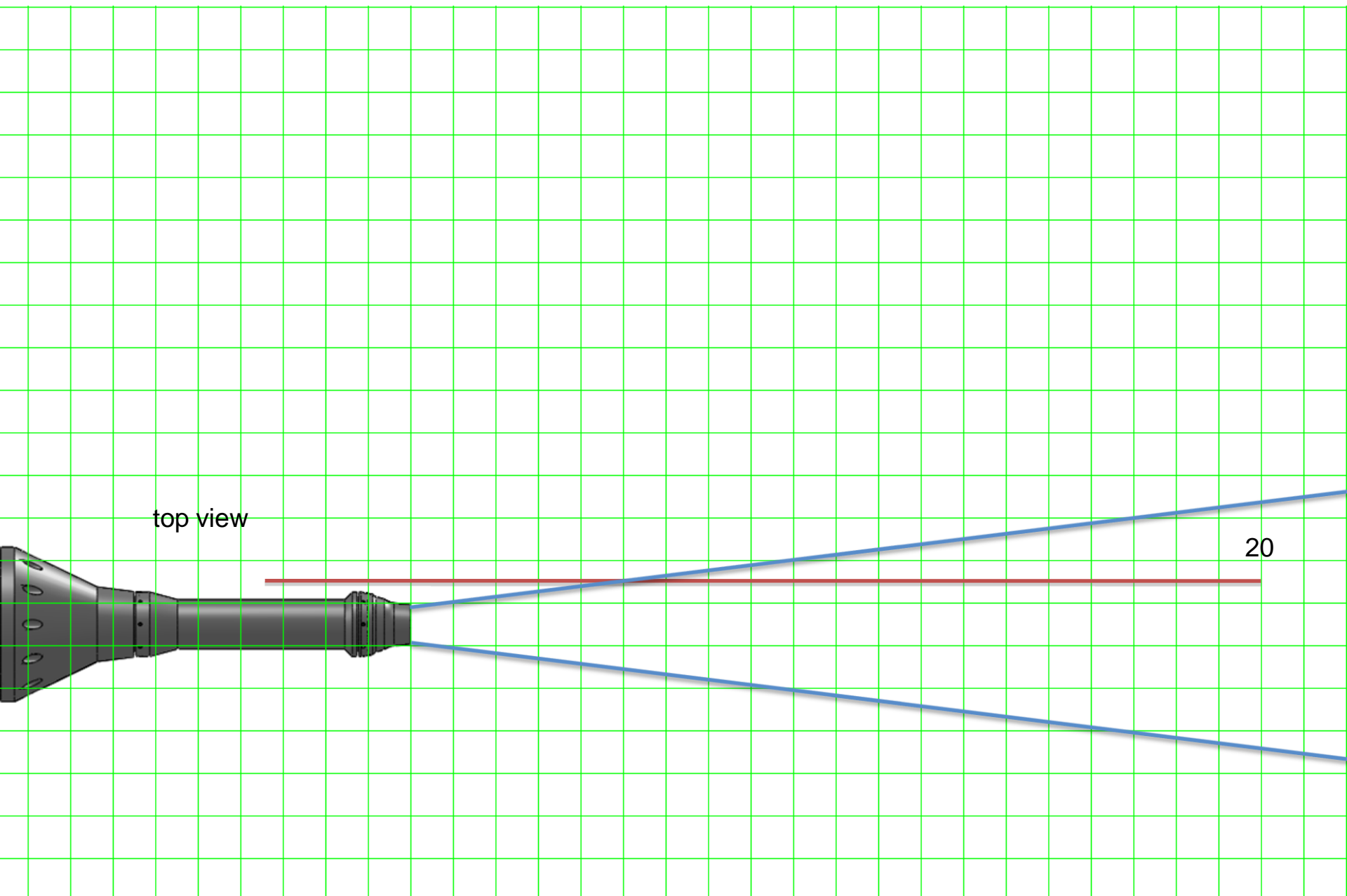




# Baseline Round Convergent Nozzle, smc000    Surface TE @ 15 Diams

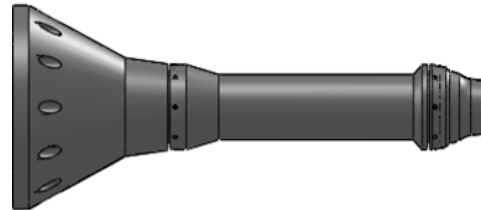


# Baseline Round Convergent Nozzle, smc000      Surface TE @ 20 Diams



## Reflecting Surface Test

### Baseline Round Convergent Nozzle, smc000

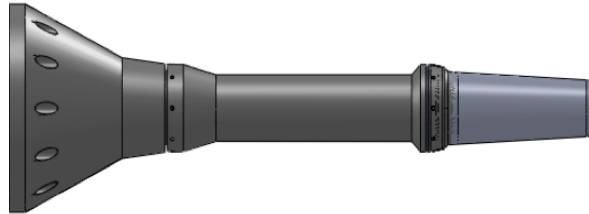


### 5 Axial X 17 Radial X 3 Set Points

Setpoint	NPR	NTR	Ma	Mj
	$P_j_{total}/P_a$	$T_j_{static}/T_a$	$V_j/c_a$	$V_j/c_{local}$
3	1.197	0.95	0.5	0.51
7	1.86	0.835	0.9	0.98
9010	3.182	0.74	1.18	1.40

# Reflecting Surface Test

## Convergent Divergent Nozzle, smc016

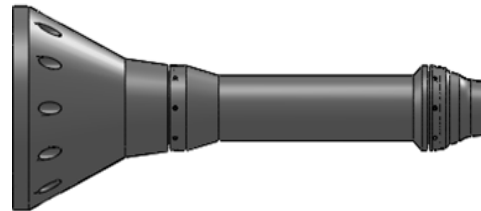


4 Axial X 17 Radial X 3 Set Points

Setpoint	NPR $P_{j\_total}/P_a$	NTR $T_{j\_static}/T_a$	Ma $V_j/c_a$	Mj $V_j/c_{local}$	
11606	2.748	0.761	1.128	1.29	Overexpanded
11610	3.670	0.706	1.31	1.5	Design
11617	4.324	0.671	1.41	1.61	Underexpanded

## Reflecting Surface Test

### Baseline Round Convergent Nozzle, smc000

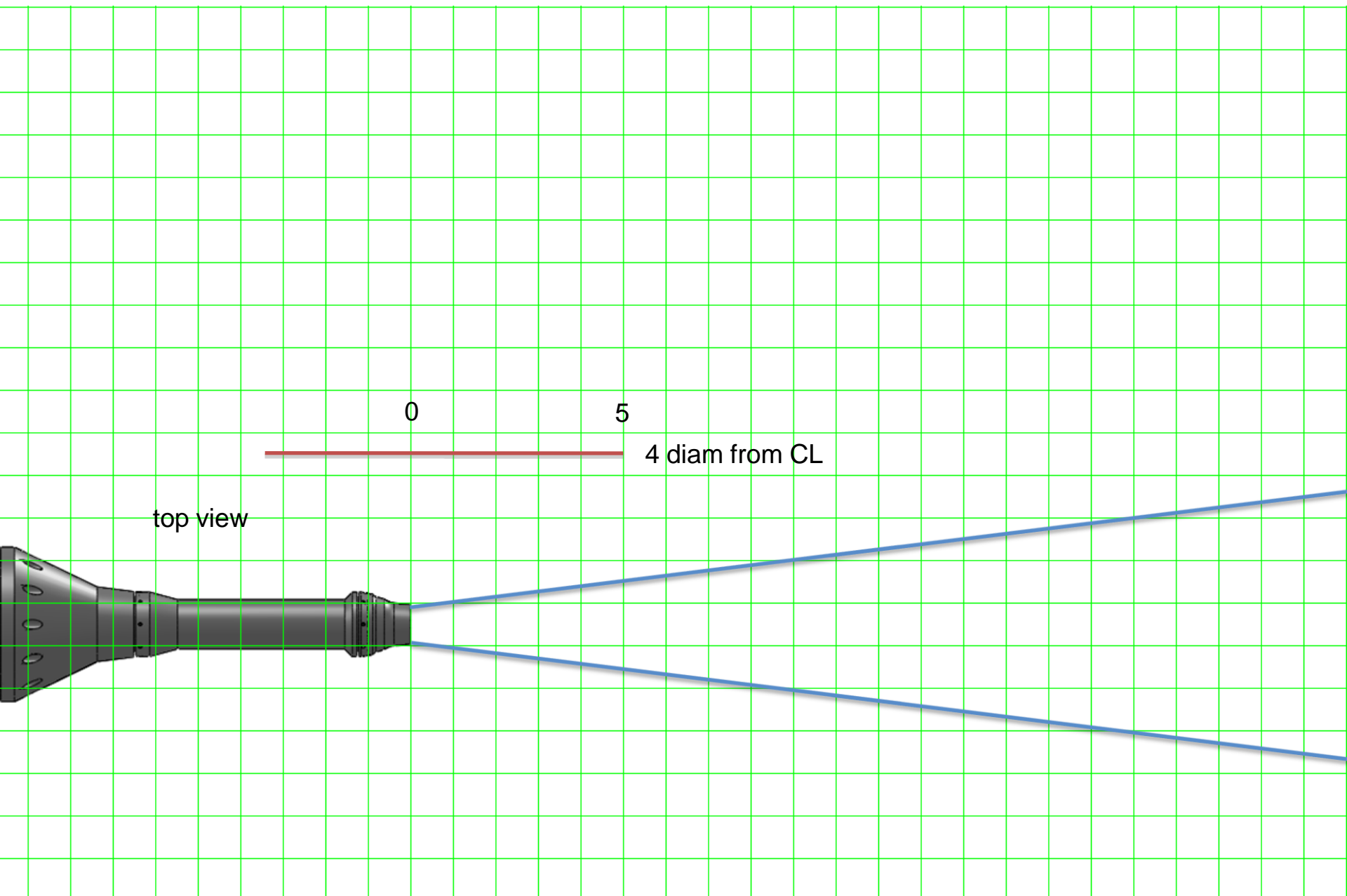


5 Axial X 17 Radial X 3 Set Points

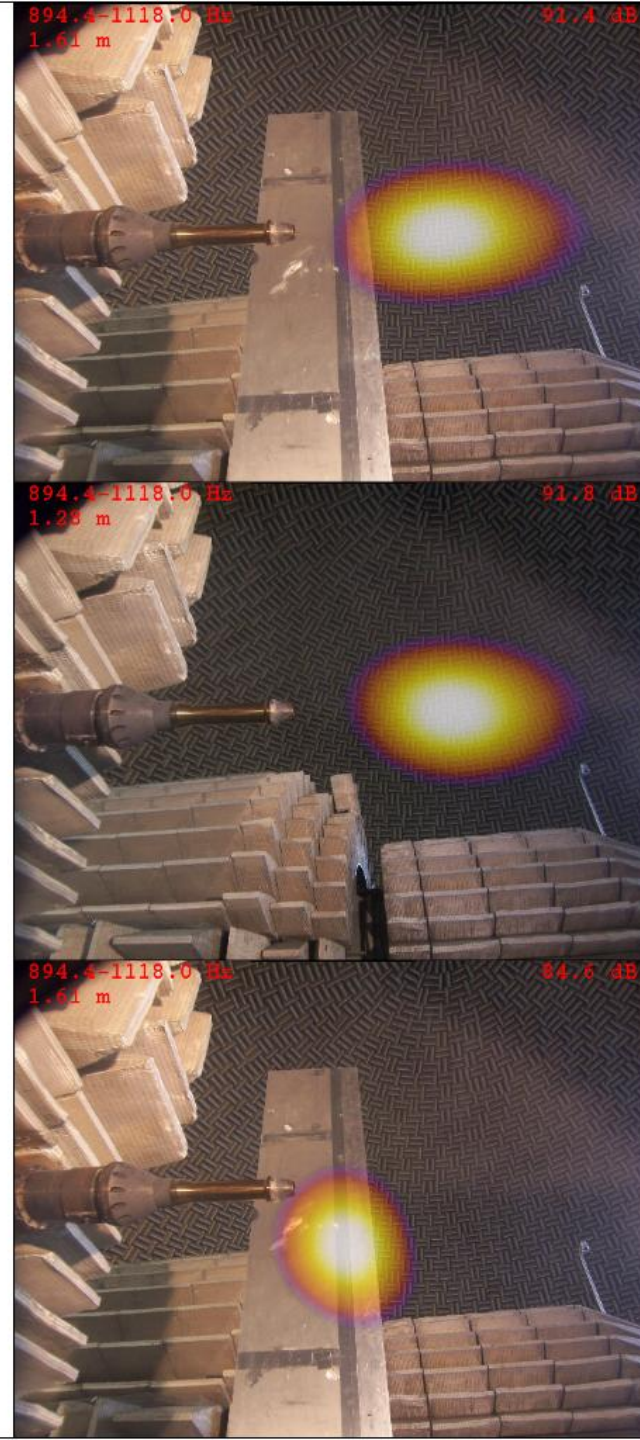
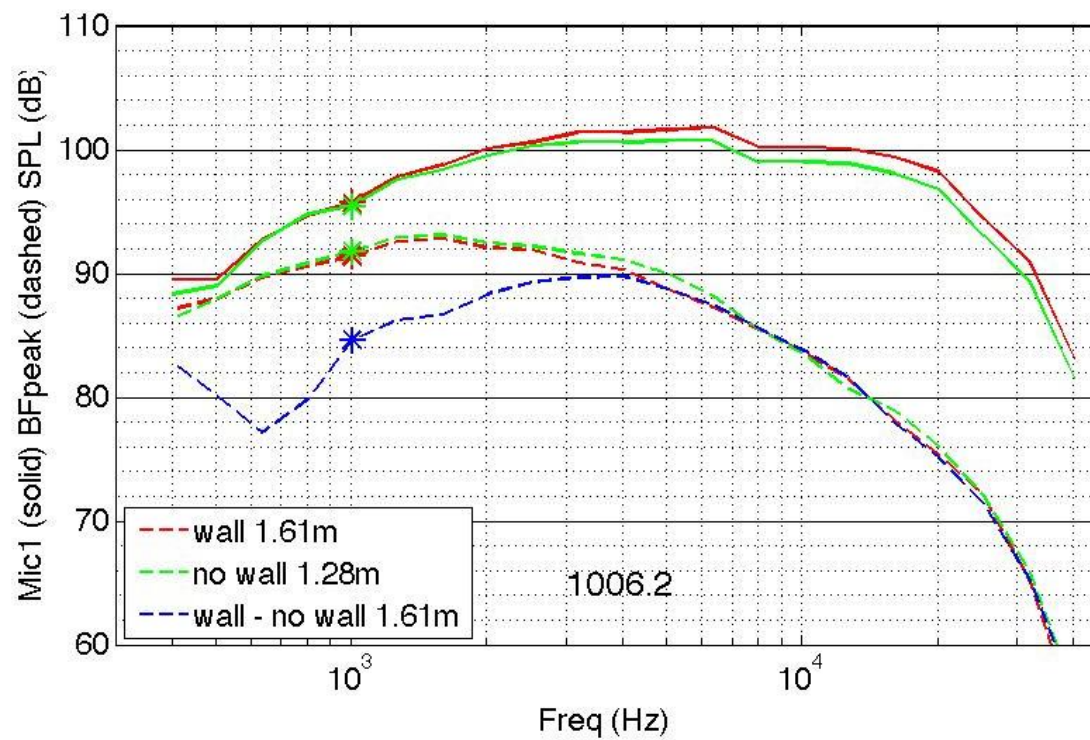
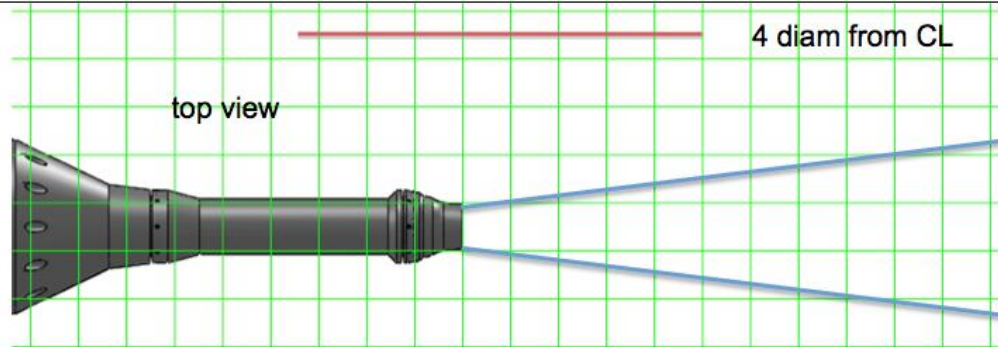
Setpoint	NPR Pj_total/Pa	NTR Tj_static/Ta	Ma Vj/ca	Mj Vj/c_local
3	1.197	0.95	0.5	0.51
7	1.86	0.835	0.9	0.98
9010	3.182	0.74	1.18	1.40

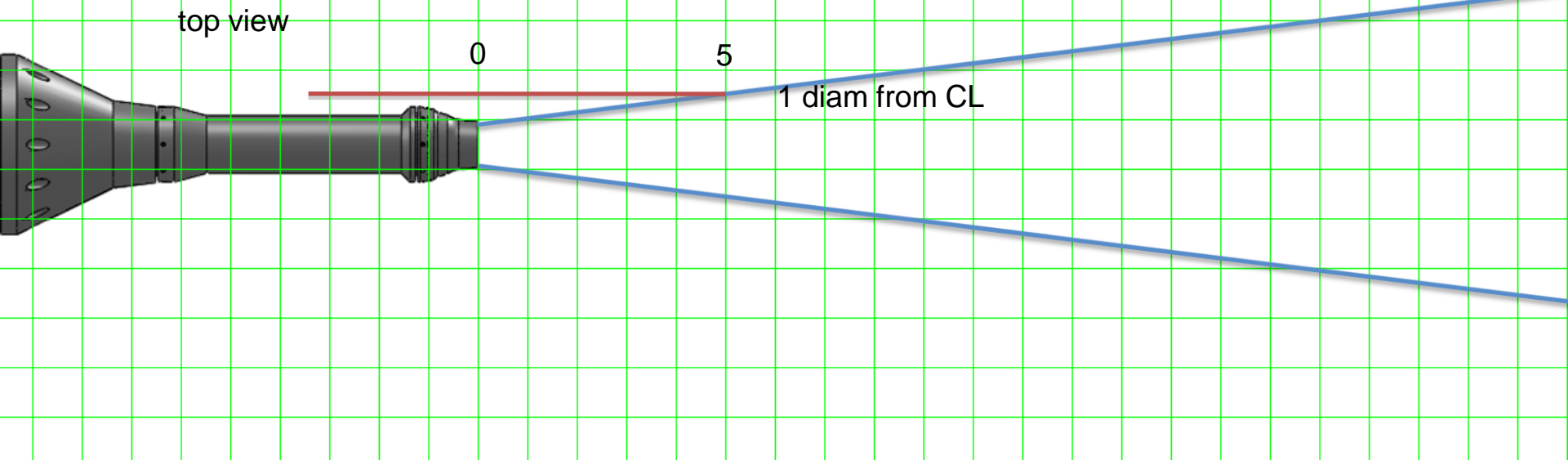
Baseline Round Convergent Nozzle, smc000

Surface TE @ 5 Diams

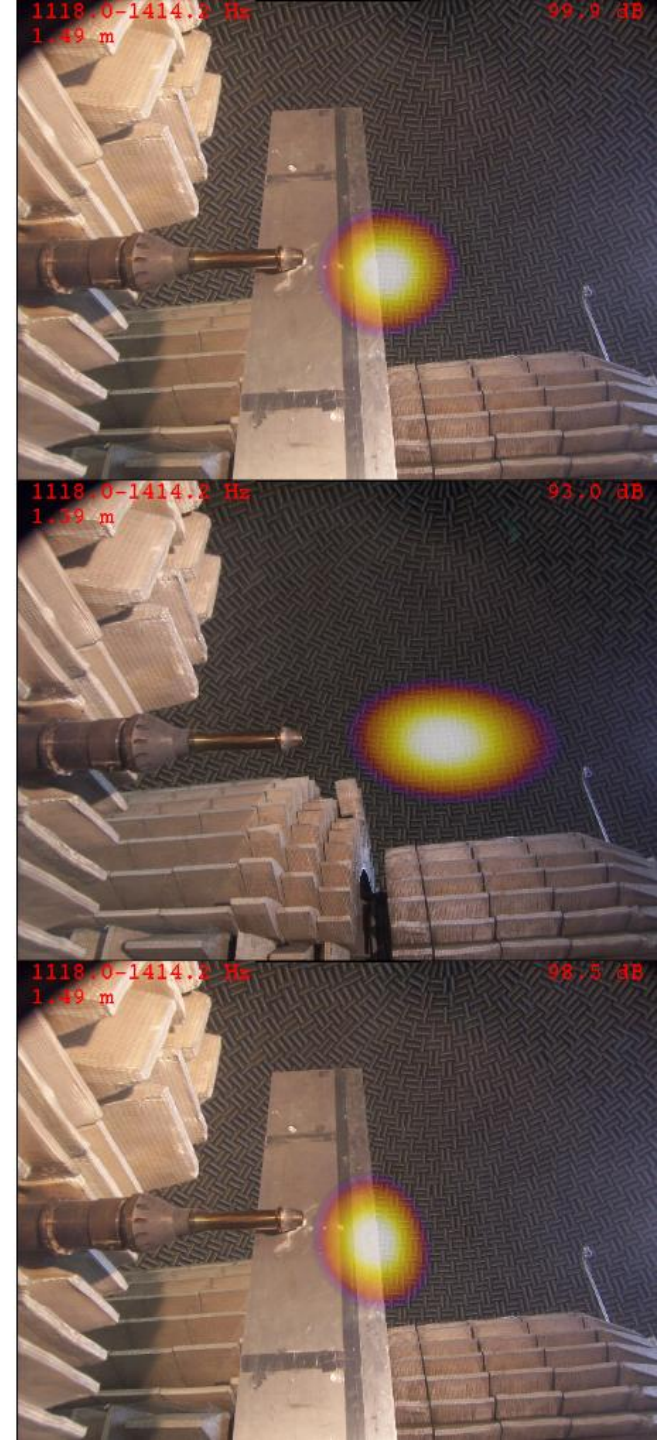
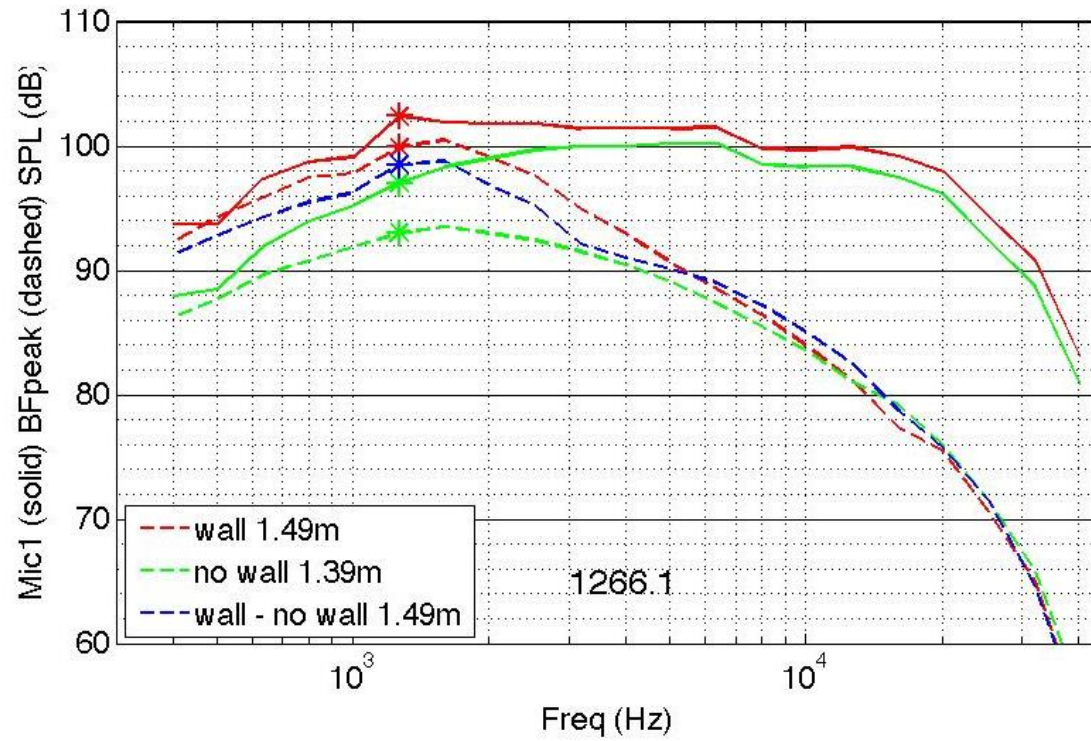
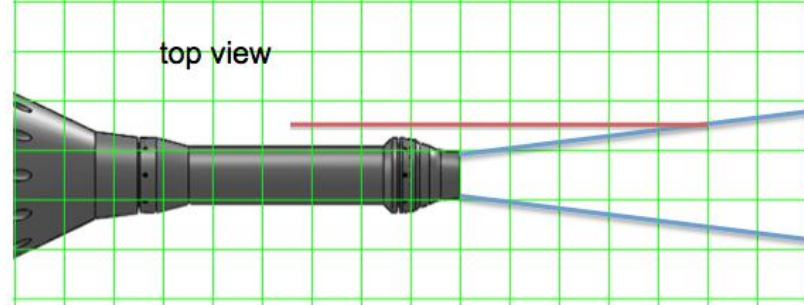




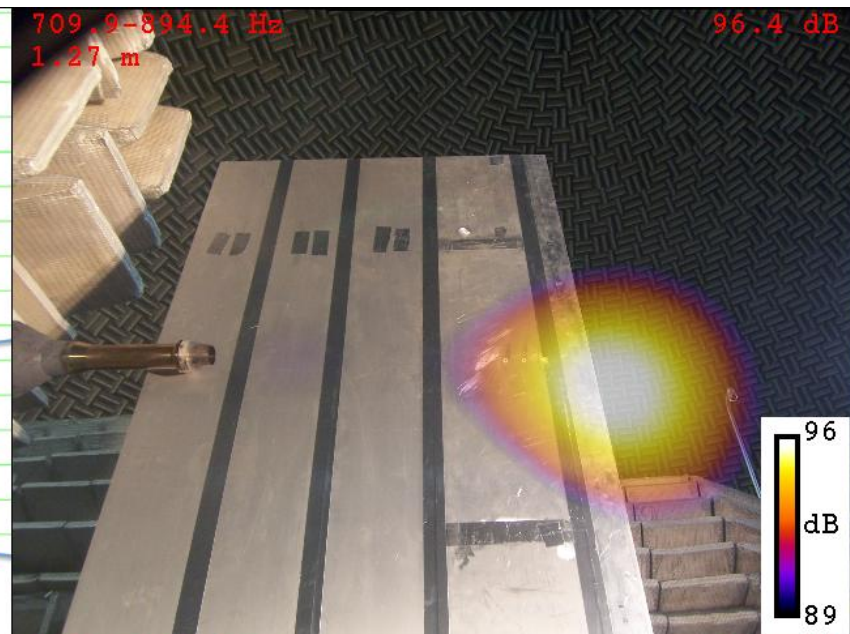
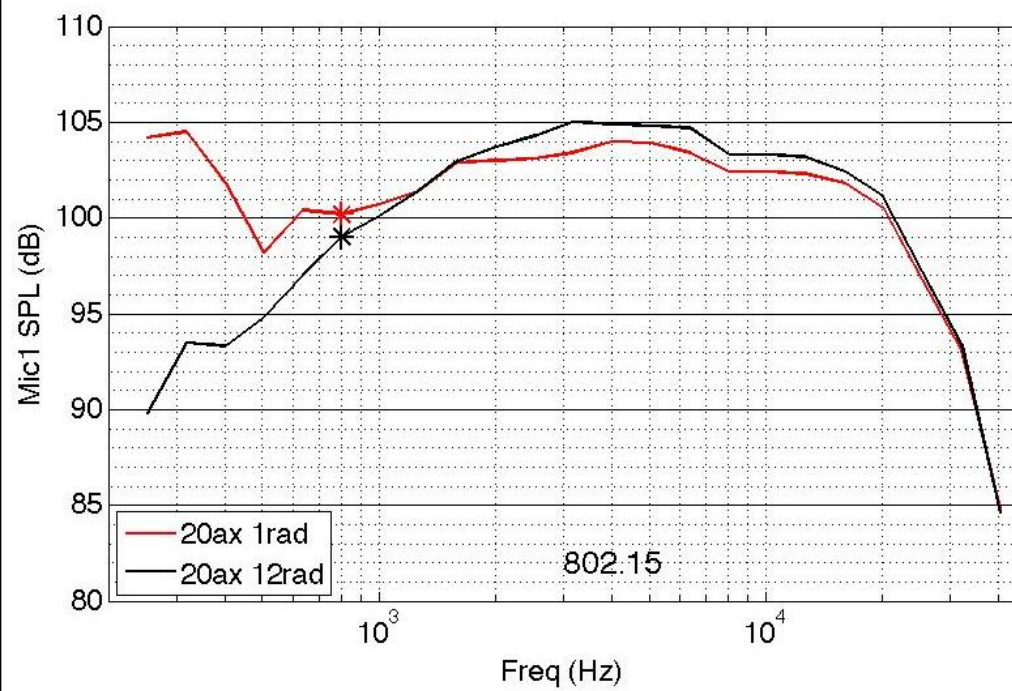
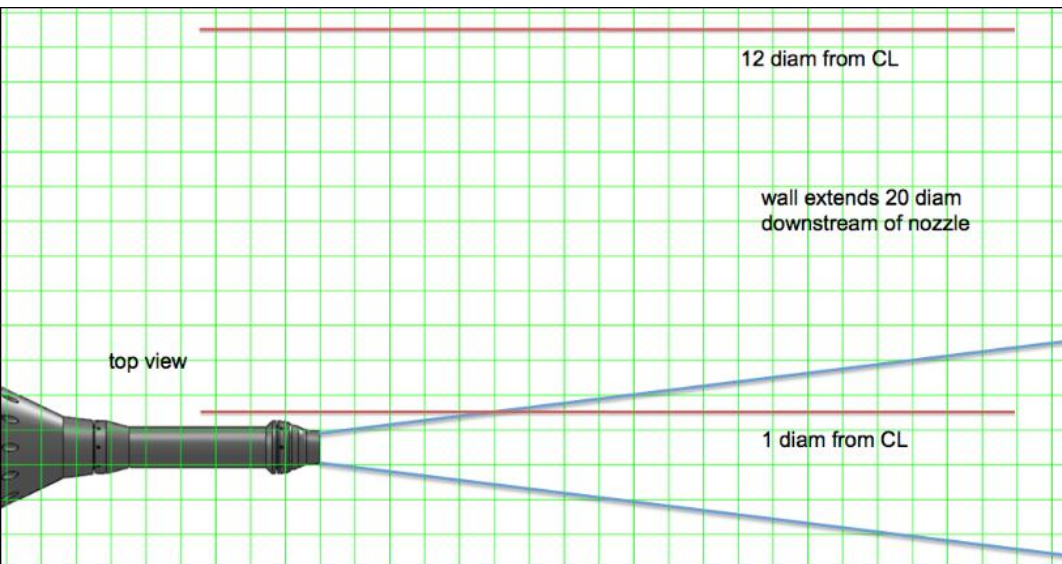








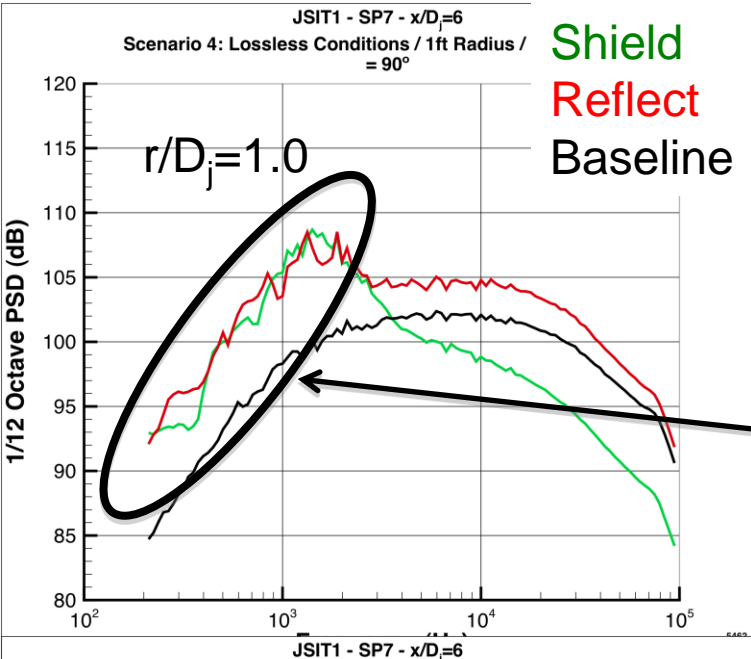




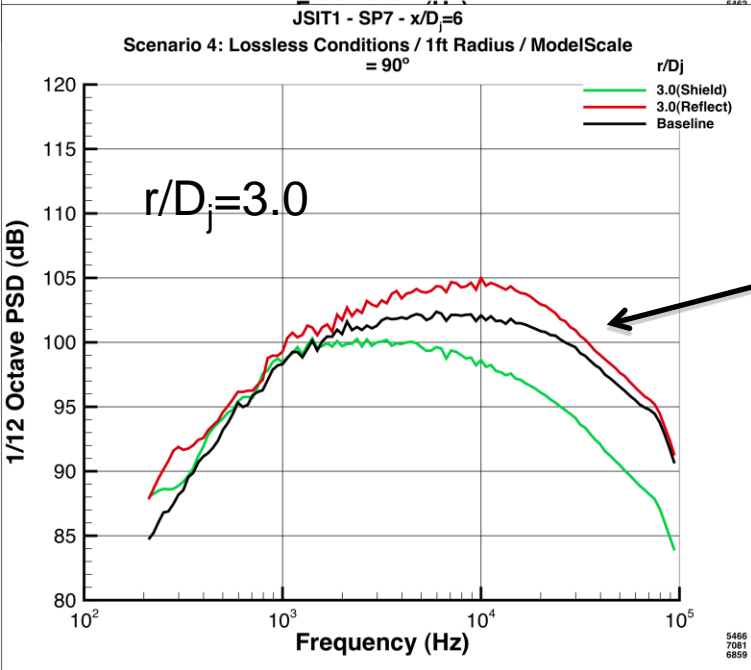


# Trailing Edge Source

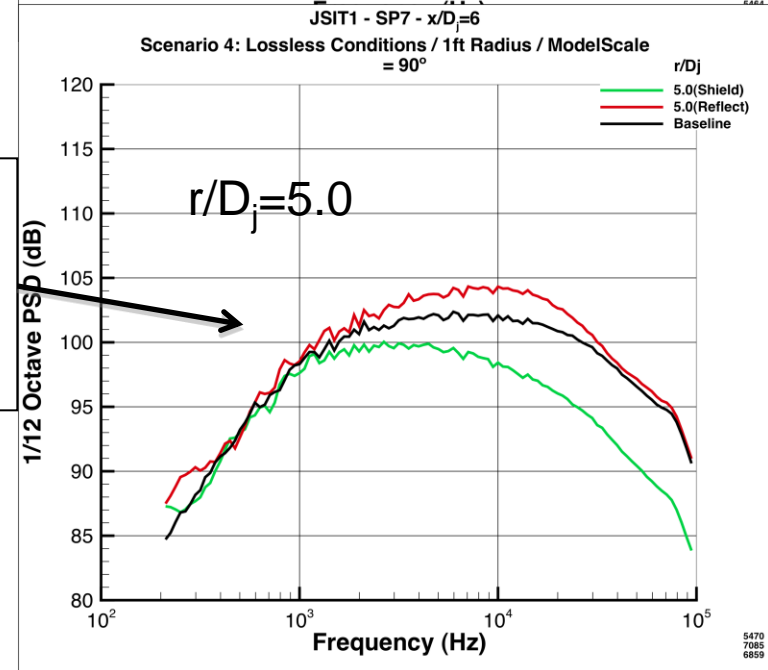
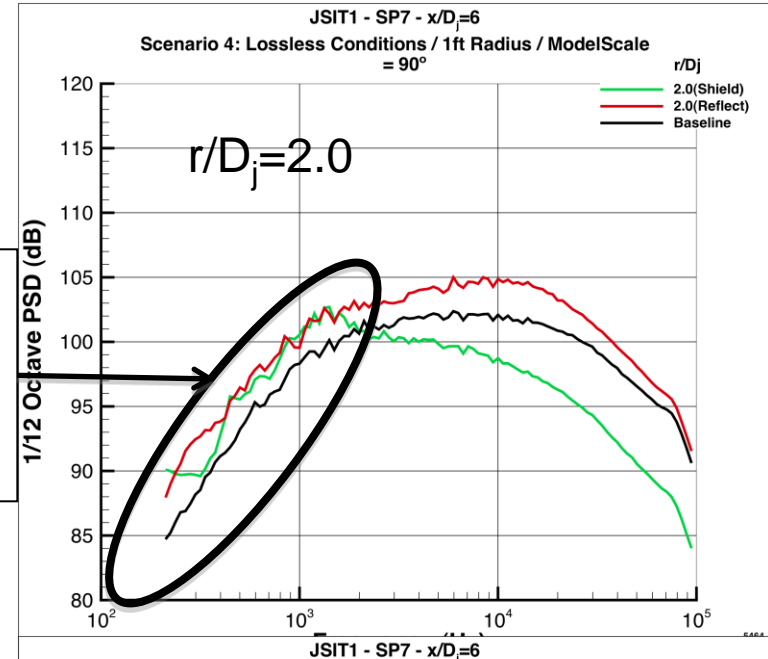
## Far-Field Acoustic Data – $x/D_j=6.0$ , $\theta=90^\circ$

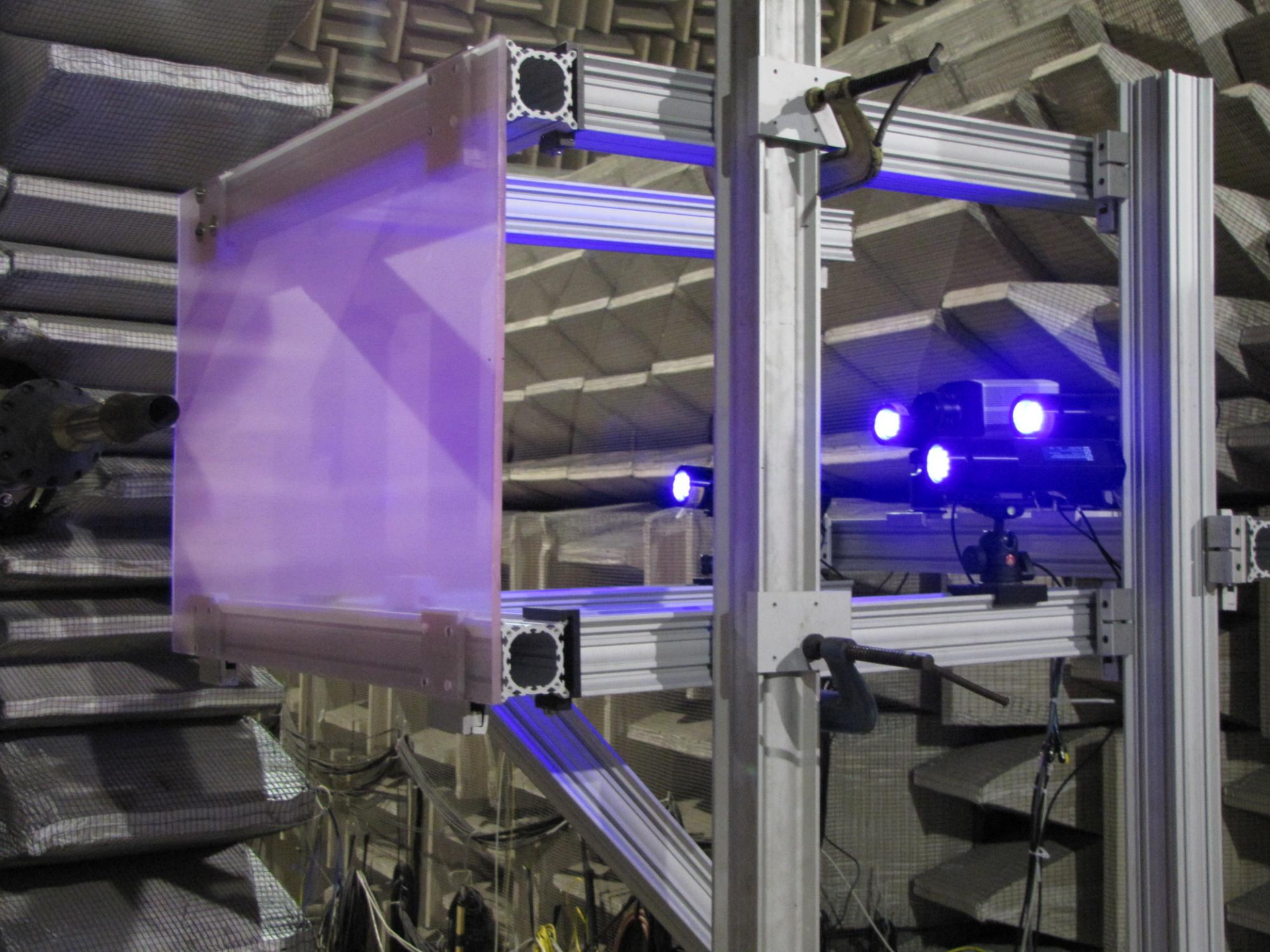


Trailing edge  
noise – same for  
shield and reflect  
configurations



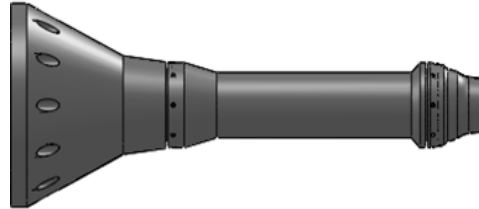
Surface out of  
the jet flow – no  
trailing edge  
noise





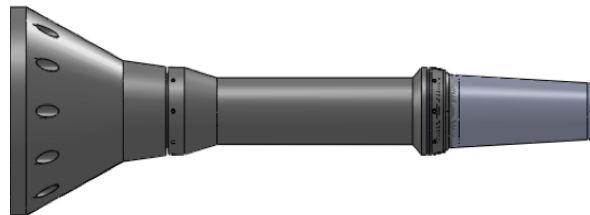
## PSP Data

### Baseline Round Convergent Nozzle, smc000



Setpoint	NPR	NTR	Ma	Mj
	$P_{j\_total}/P_a$	$T_{j\_static}/T_a$	$V_j/c_a$	$V_j/c_{local}$
3	1.197	0.95	0.5	0.51
7	1.86	0.835	0.9	0.98
9010	3.182	0.74	1.18	1.40

### Convergent Divergent Nozzle, smc016



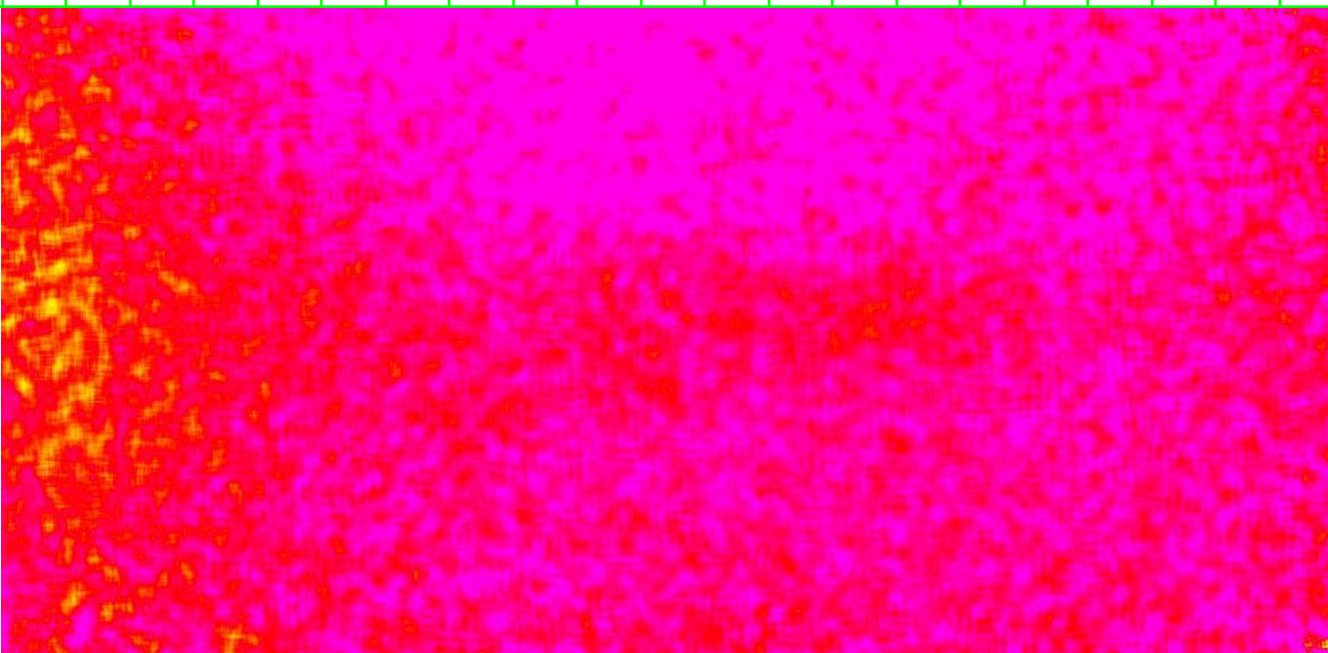
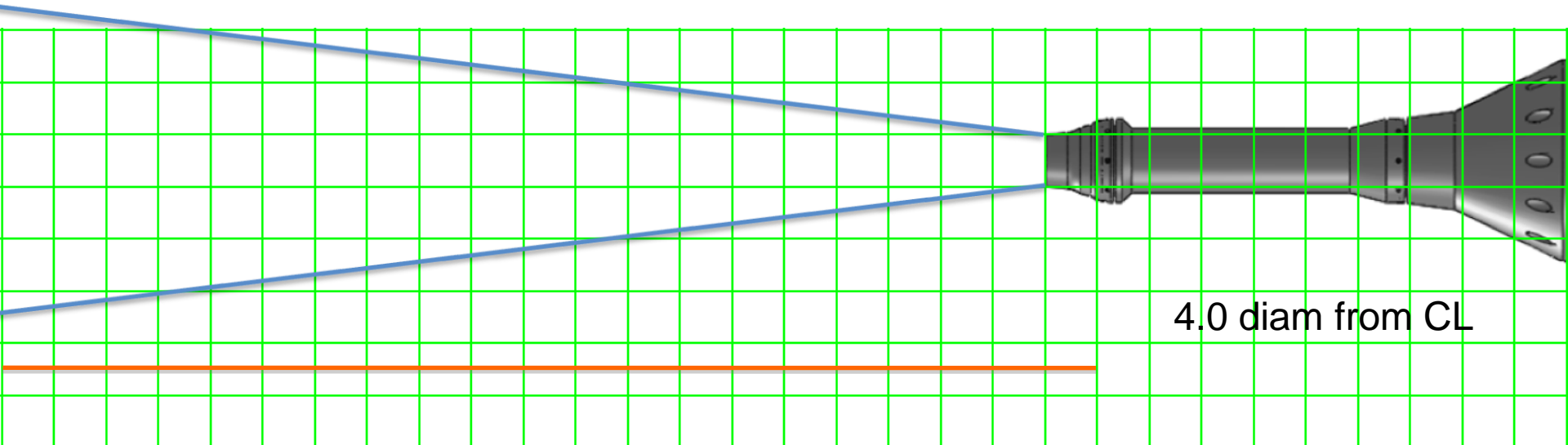
Setpoint	NPR	NTR	Ma	Mj	
	$P_{j\_total}/P_a$	$T_{j\_static}/T_a$	$V_j/c_a$	$V_j/c_{local}$	
11606	2.748	0.761	1.128	1.29	Overexpanded
11610	3.670	0.706	1.31	1.5	Design
11617	4.324	0.671	1.41	1.61	Underexpanded



SMC000 RC Nozzle

Set Point 7

$M_a=0.9$



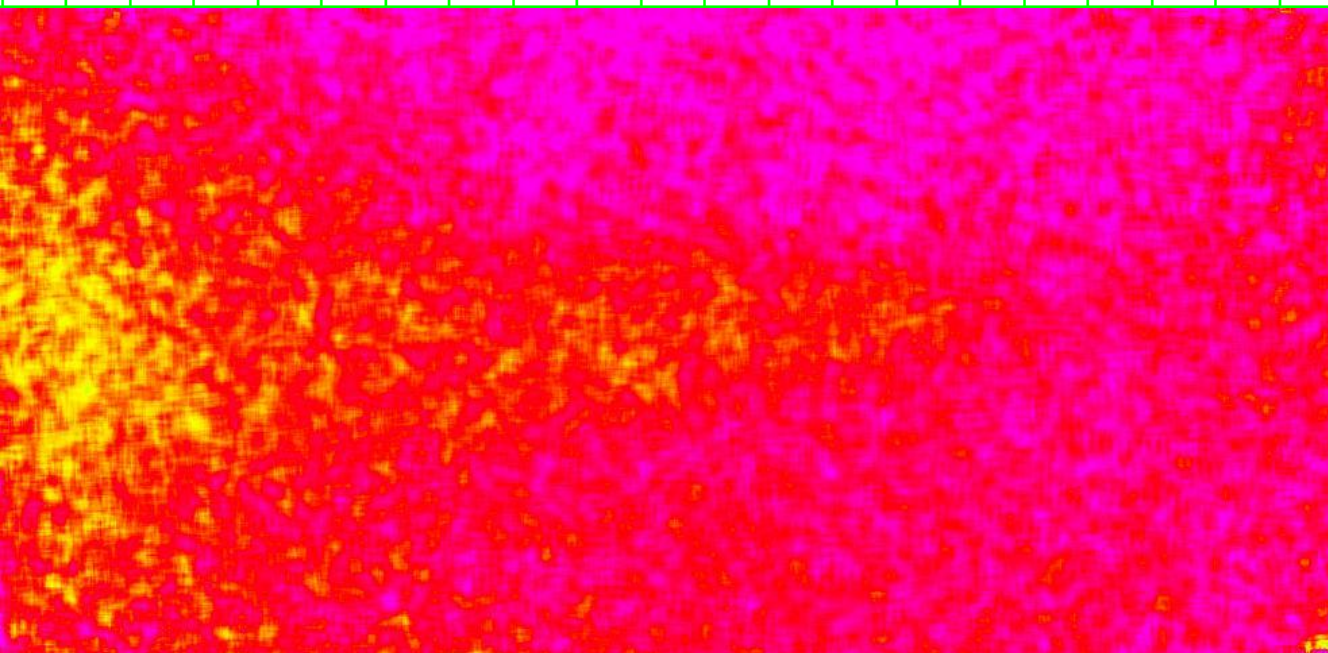
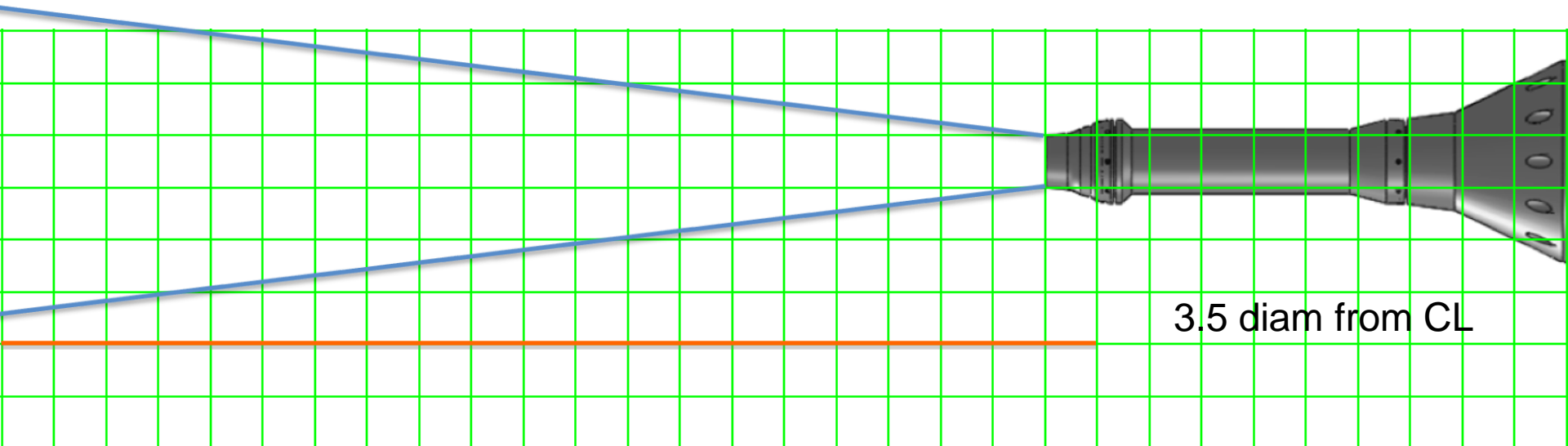
1.00  
Pressure  
Ratio  
0.98



SMC000 RC Nozzle

Set Point 7

$M_a=0.9$

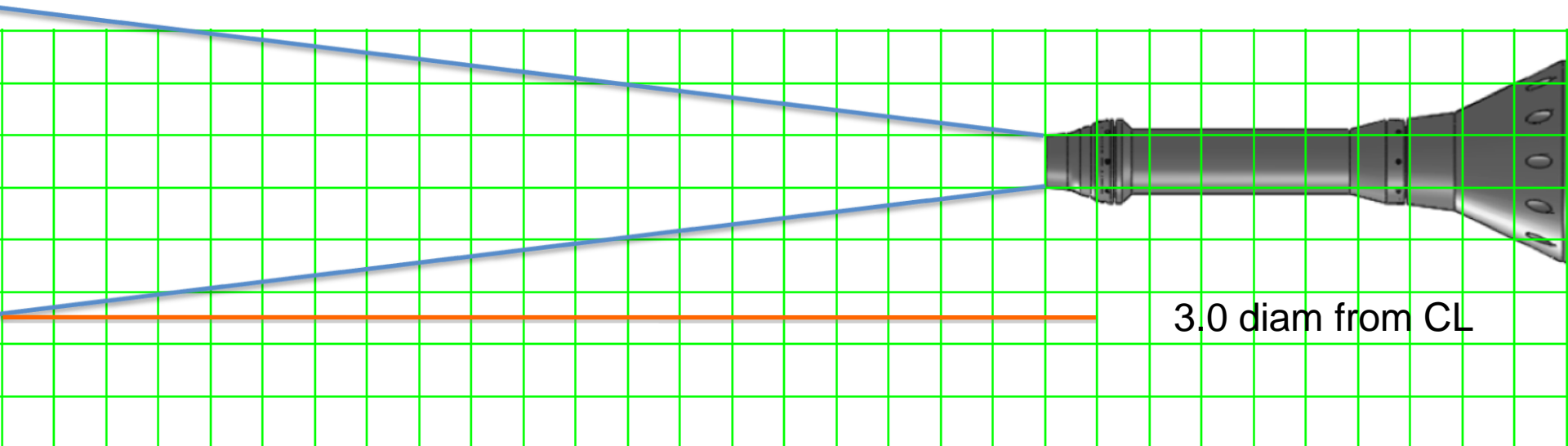


1.00  
Pressure  
Ratio  
0.98

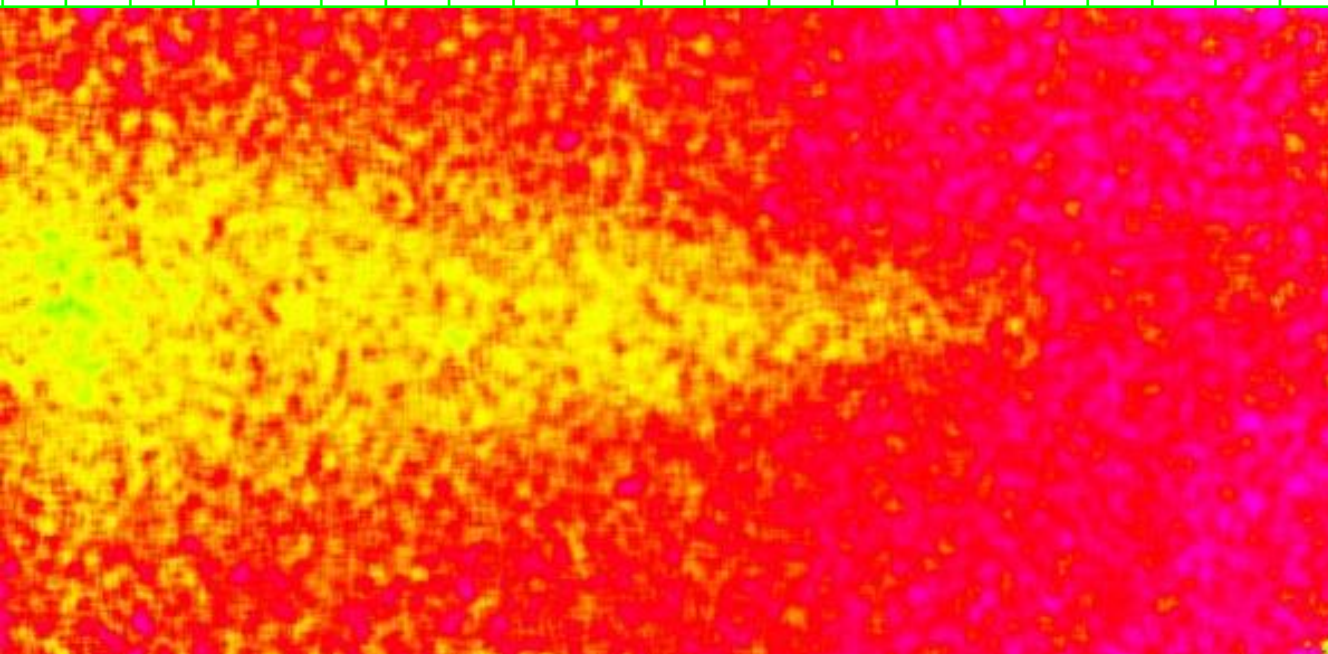
SMC000 RC Nozzle

Set Point 7

$M_a=0.9$



3.0 diam from CL



Pressure  
Ratio

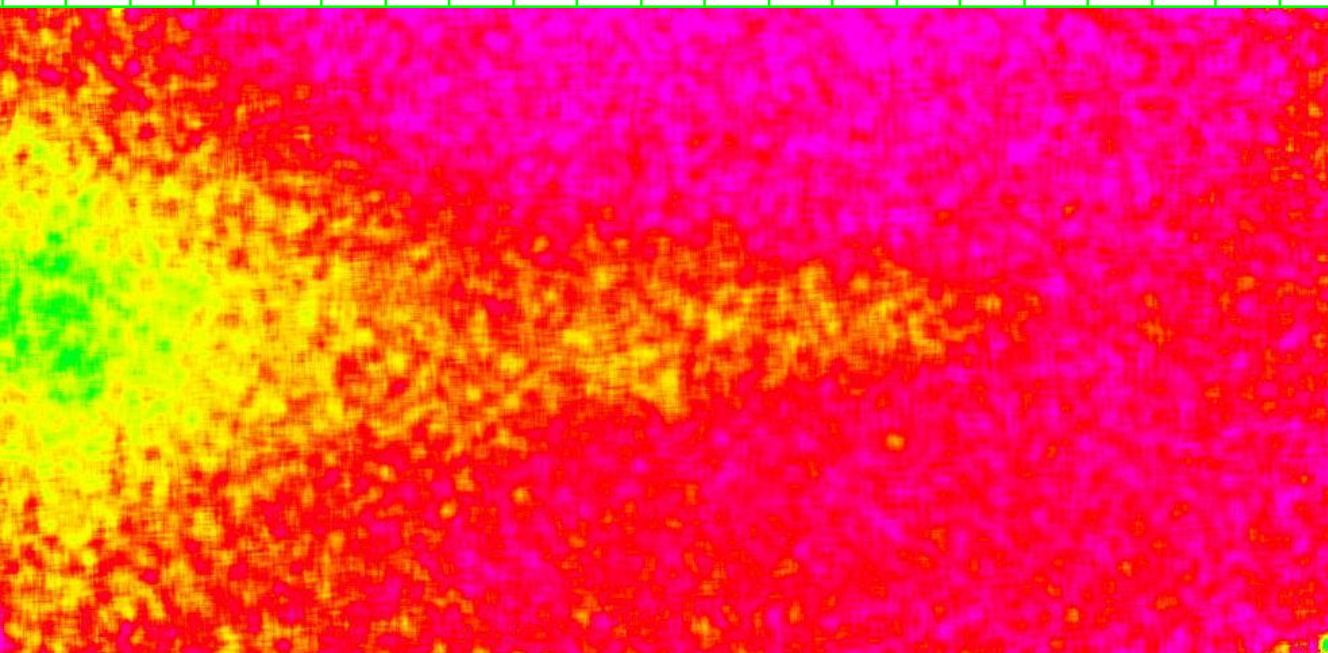
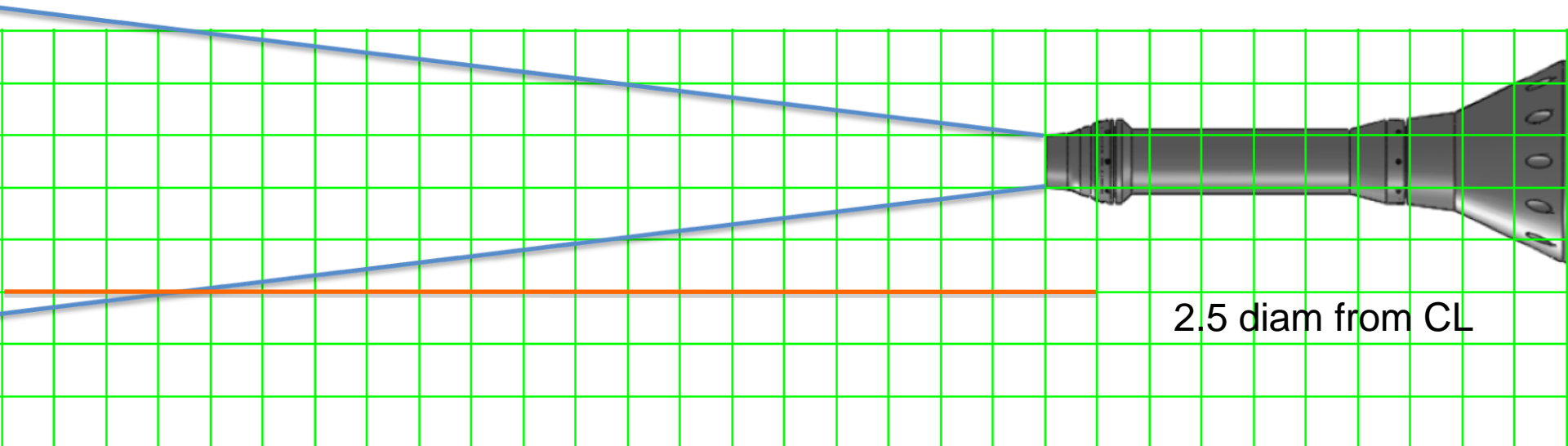
1.00

0.98

SMC000 RC Nozzle

Set Point 7

$M_a=0.9$



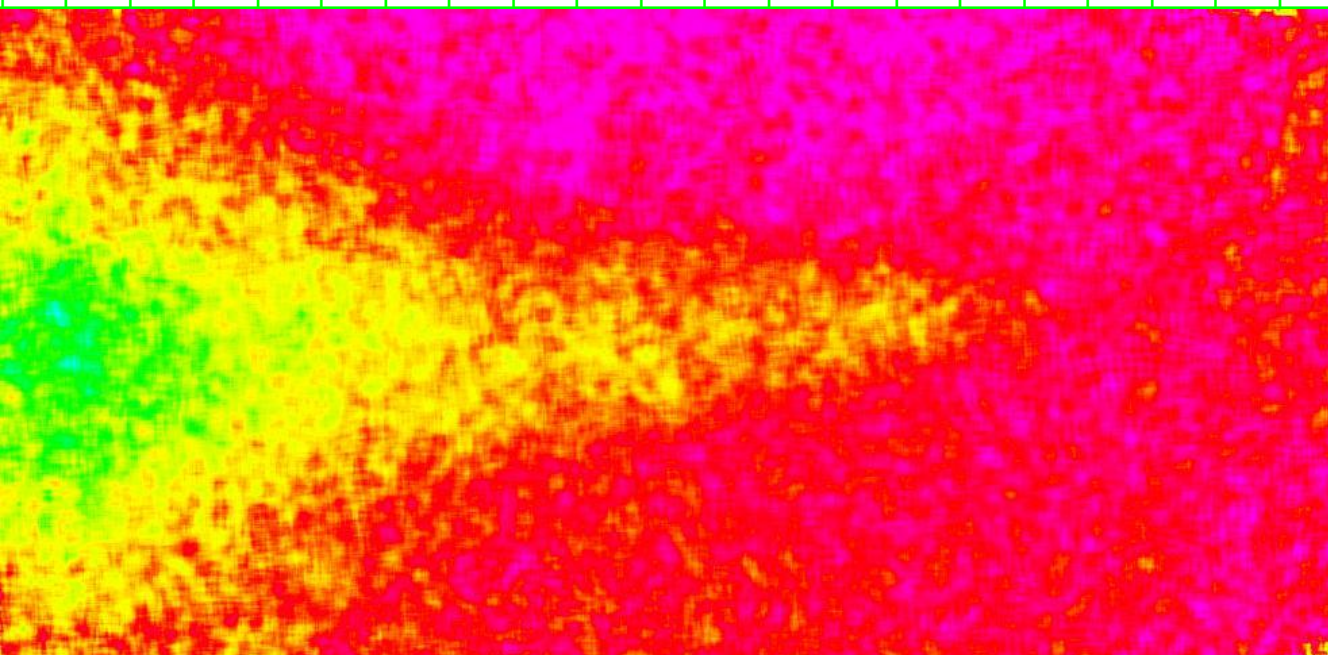
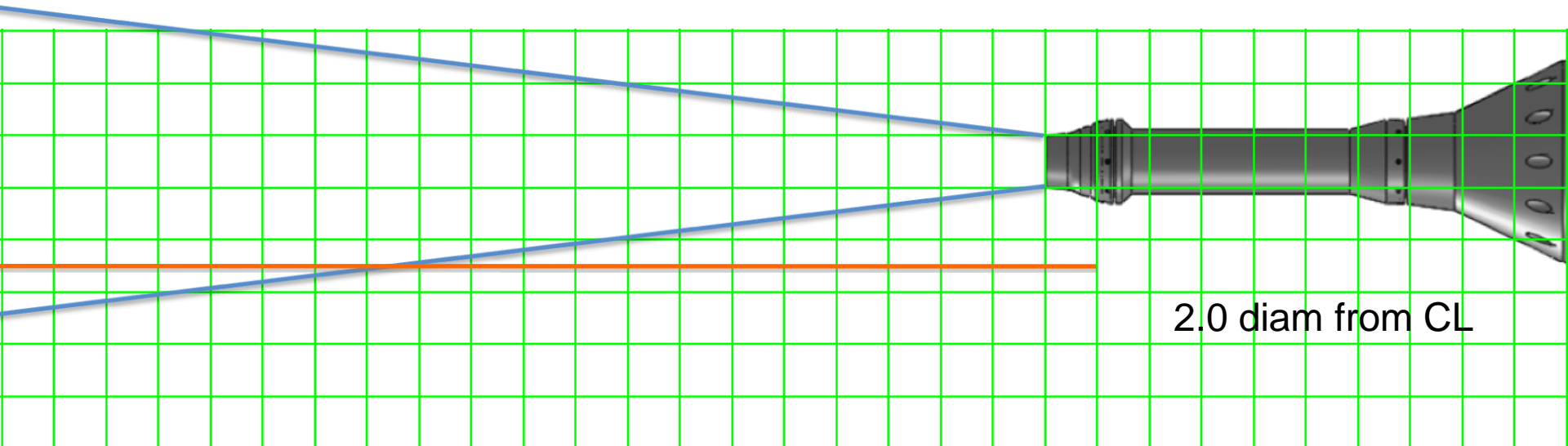
1.00  
Pressure  
Ratio  
0.98



SMC000 RC Nozzle

Set Point 7

$M_a=0.9$



Pressure  
Ratio

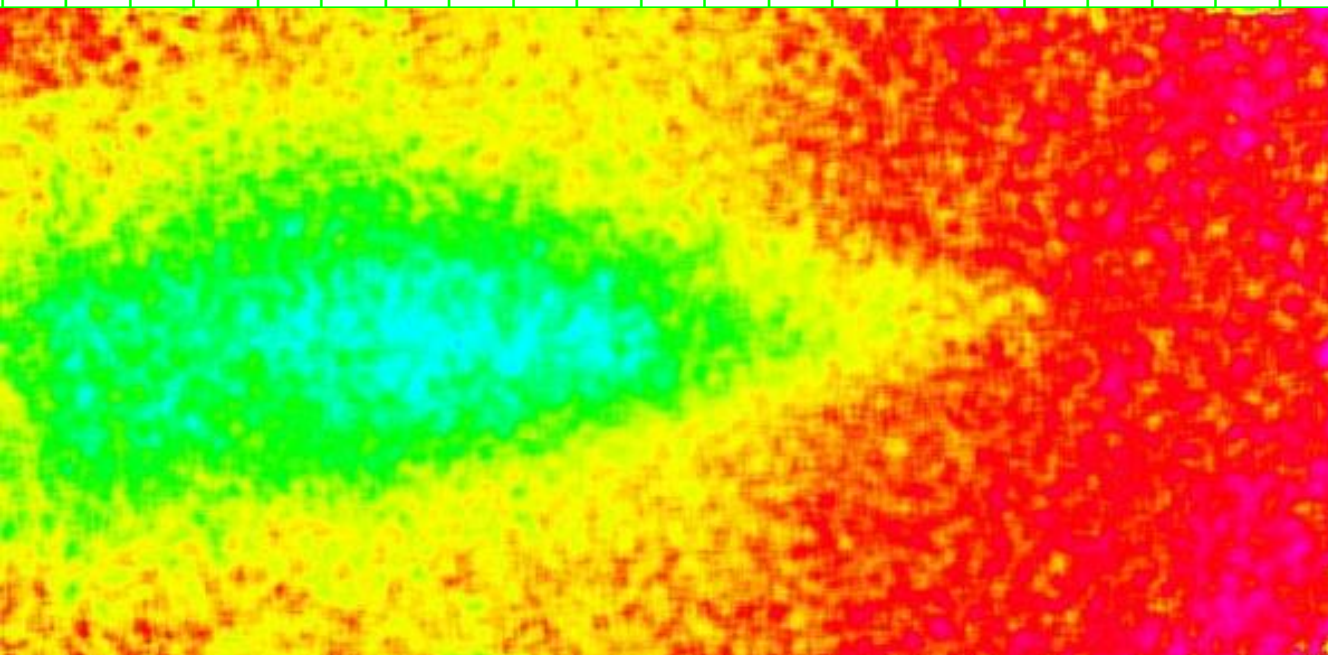
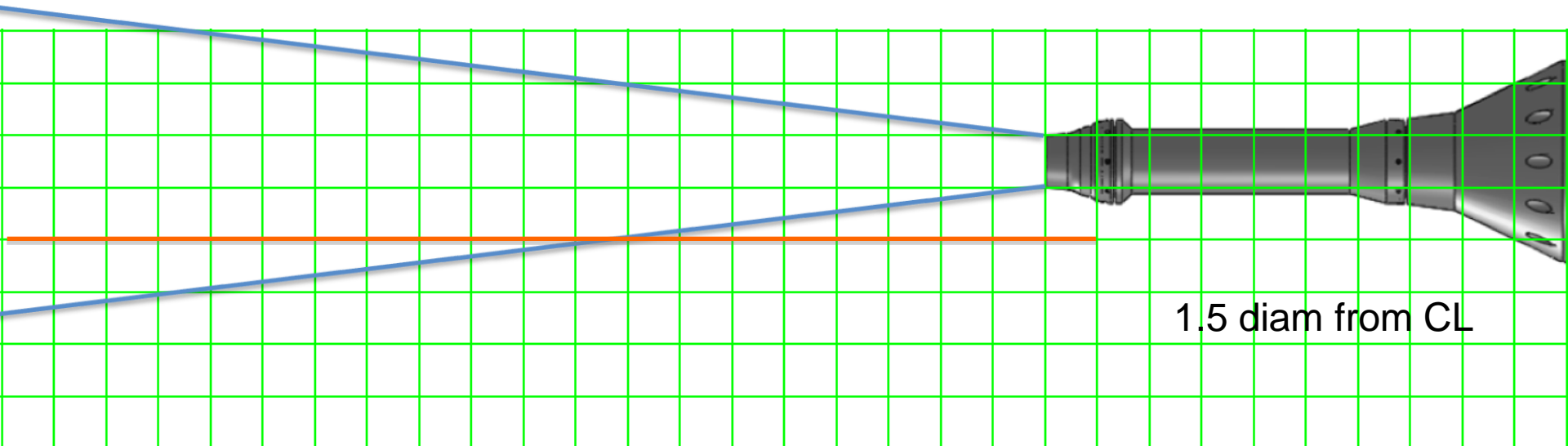
1.00

0.98

SMC000 RC Nozzle

Set Point 7

$M_a=0.9$



Pressure  
Ratio

1.00

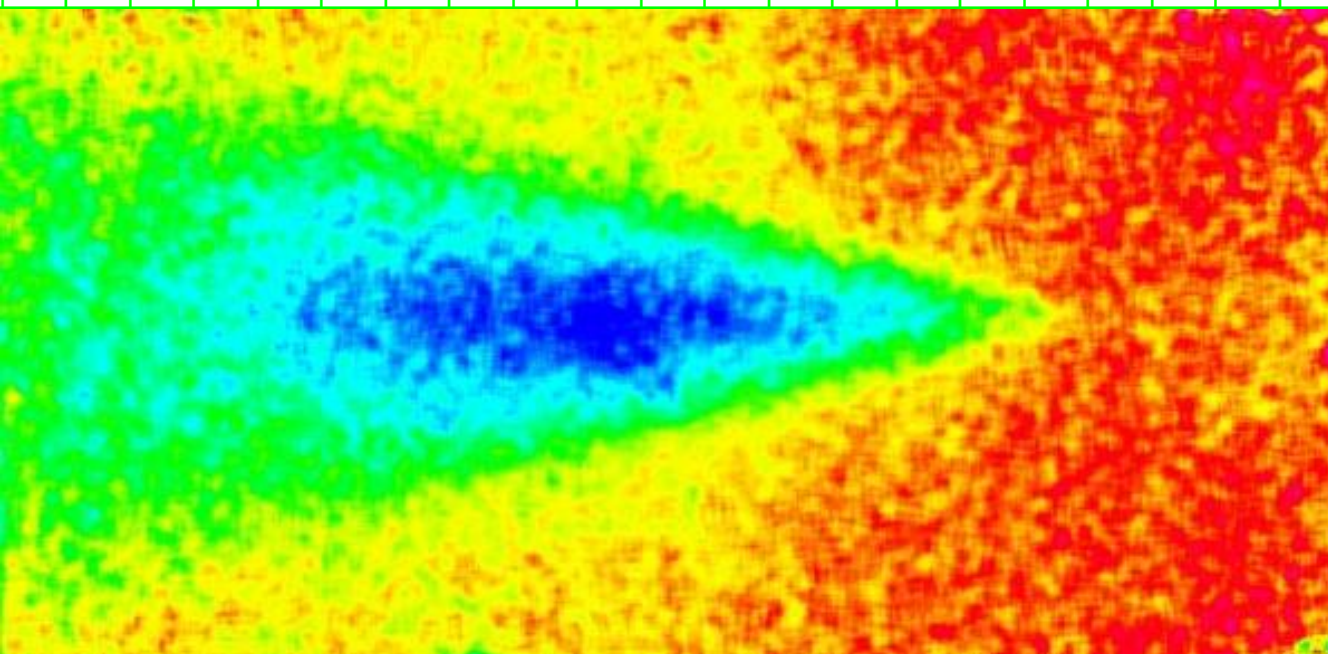
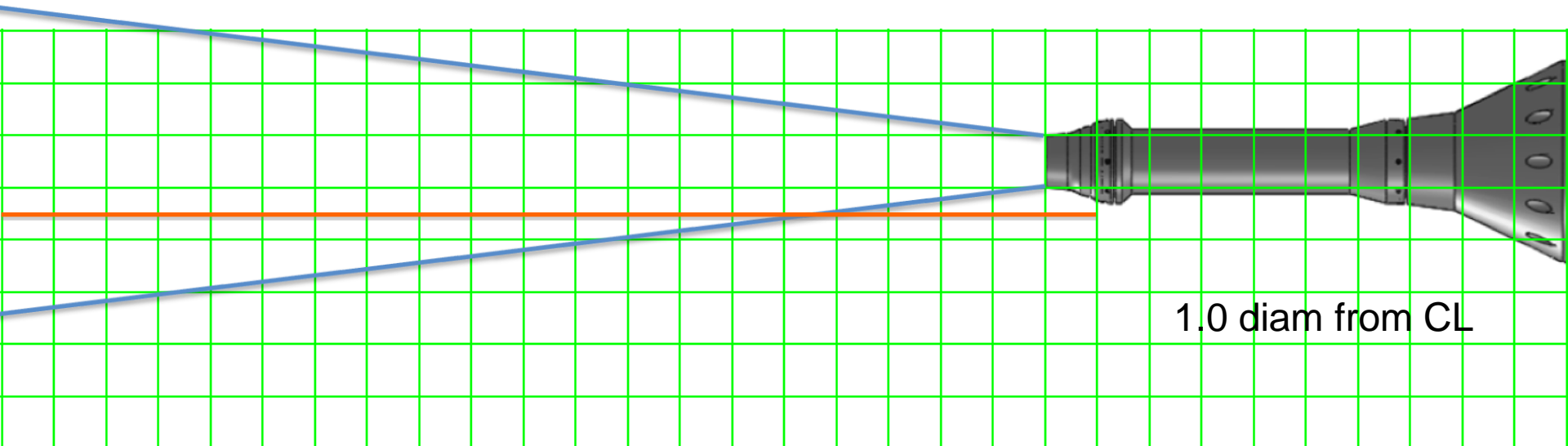
0.98



SMC000 RC Nozzle

Set Point 7

$M_a=0.9$



Pressure  
Ratio

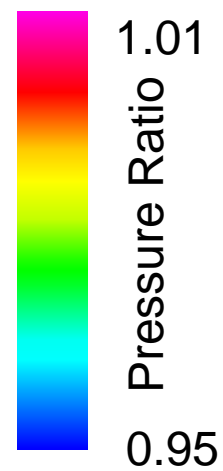
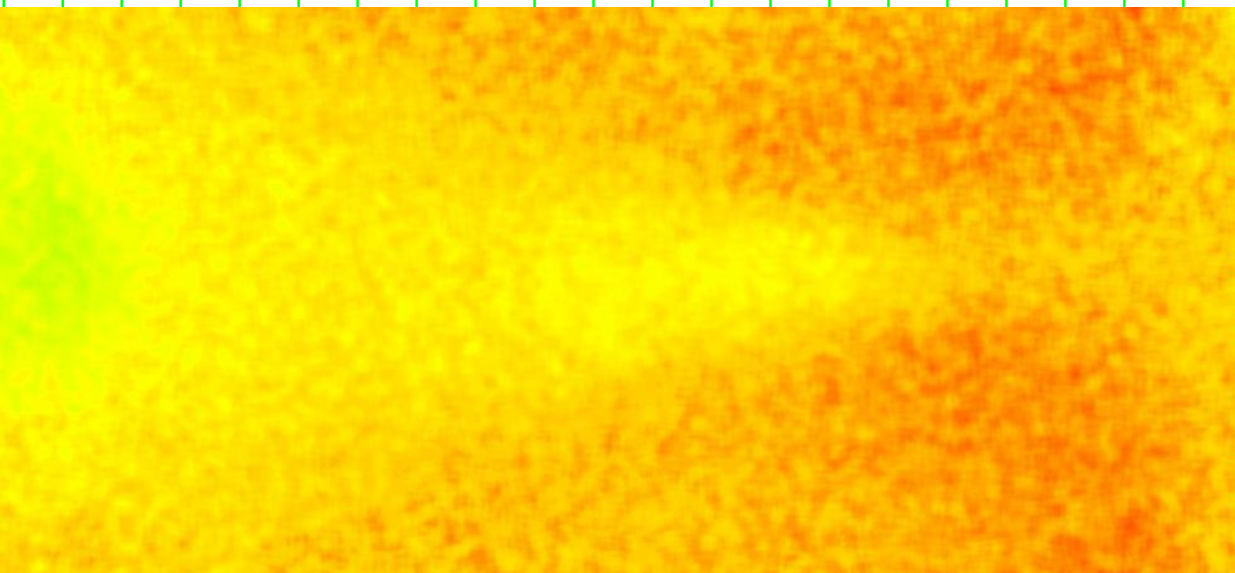
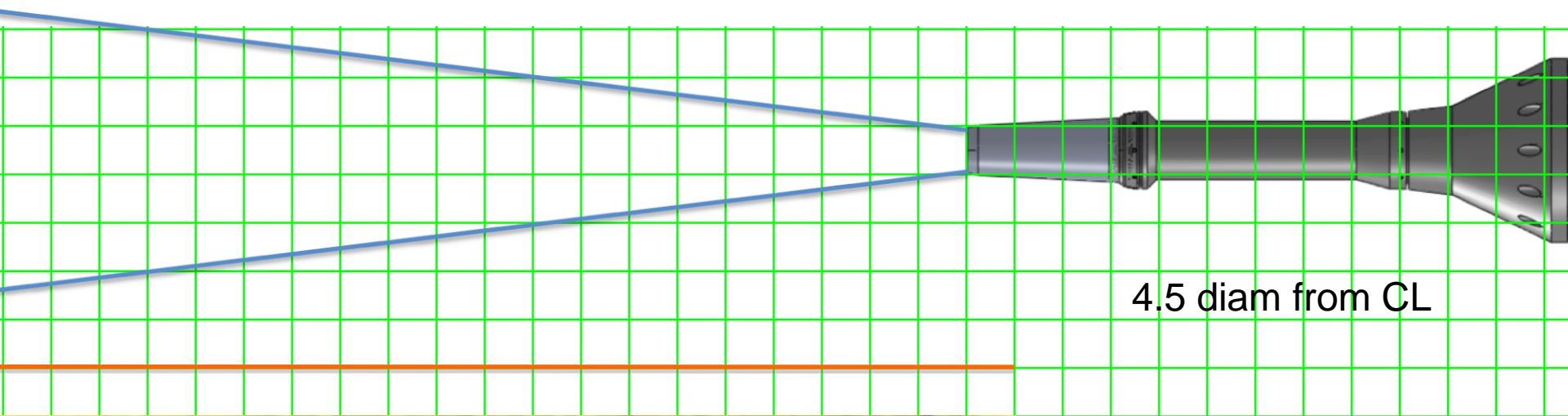
1.00

0.98

SMC016 CD Nozzle

Set Point 11606

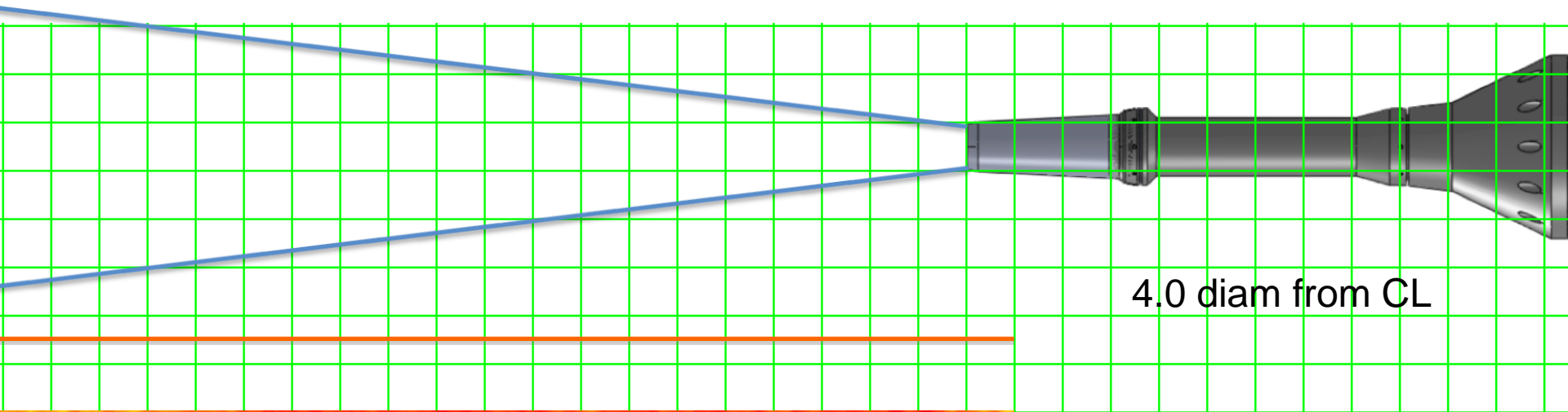
$M_{\text{jet}}=1.3$   $M_d=1.5$



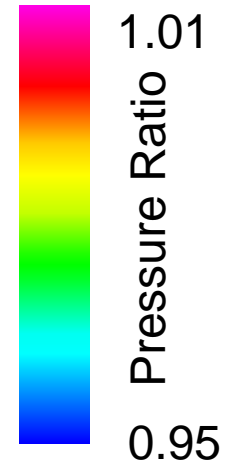
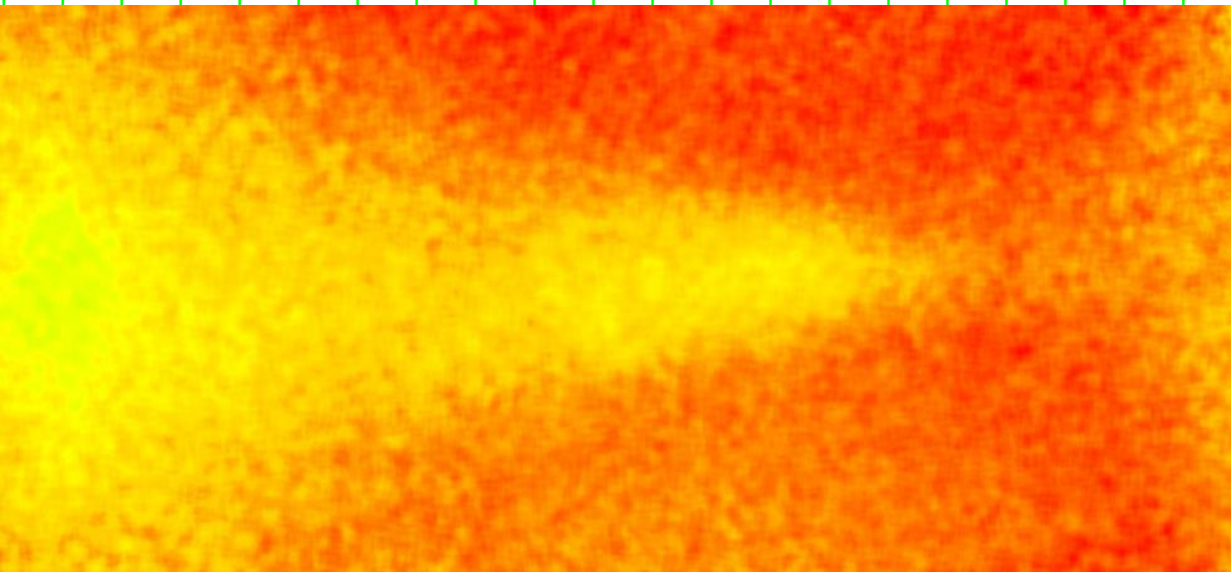
SMC016 CD Nozzle

Set Point 11606

$M_{\text{jet}}=1.3$   $M_d=1.5$



4.0 diam from CL



1.01

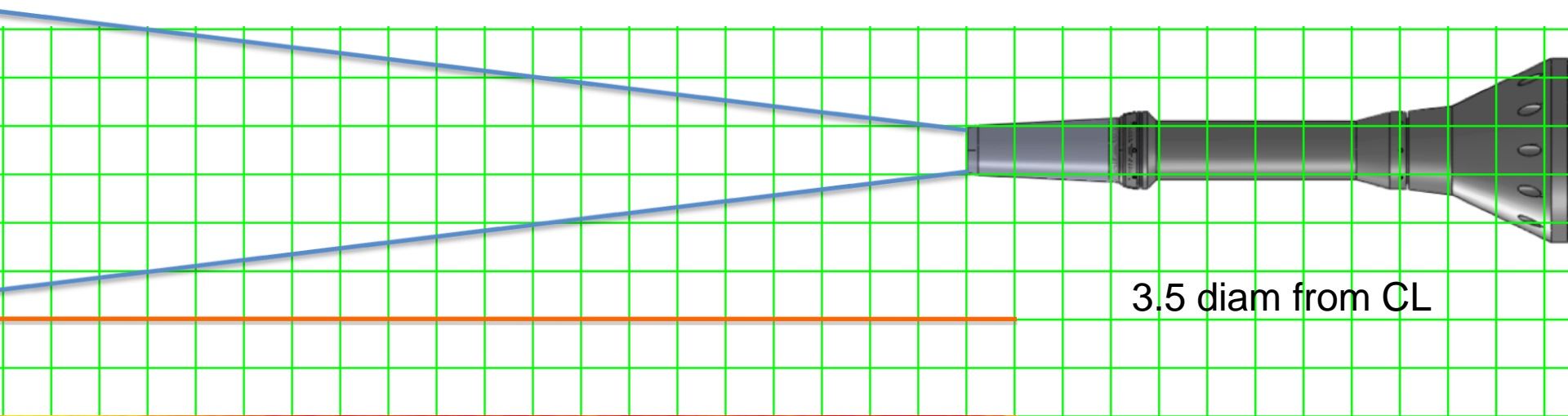
Pressure Ratio

0.95

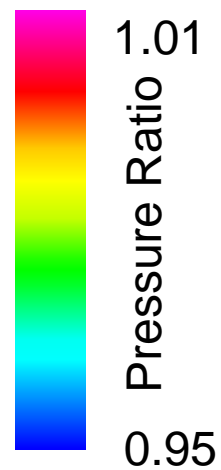
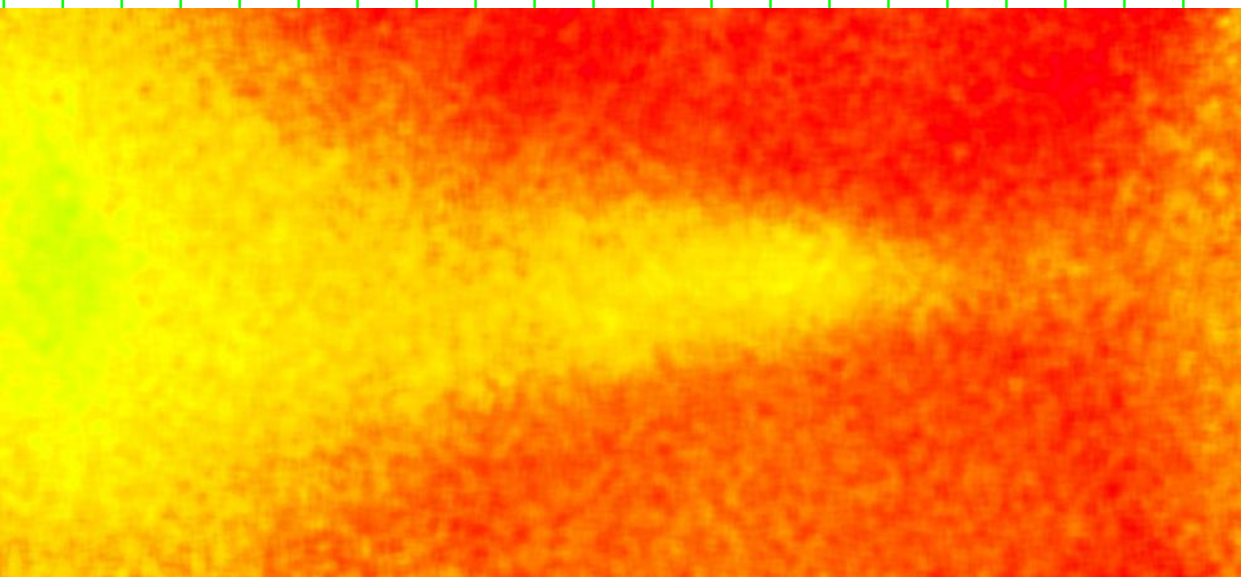
SMC016 CD Nozzle

Set Point 11606

$M_{\text{jet}}=1.3$   $M_d=1.5$



3.5 diam from CL



1.01

Pressure Ratio

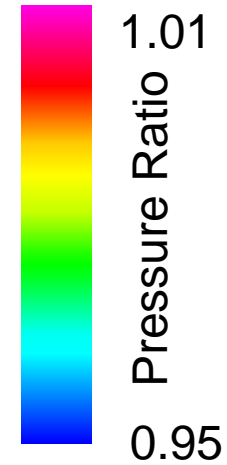
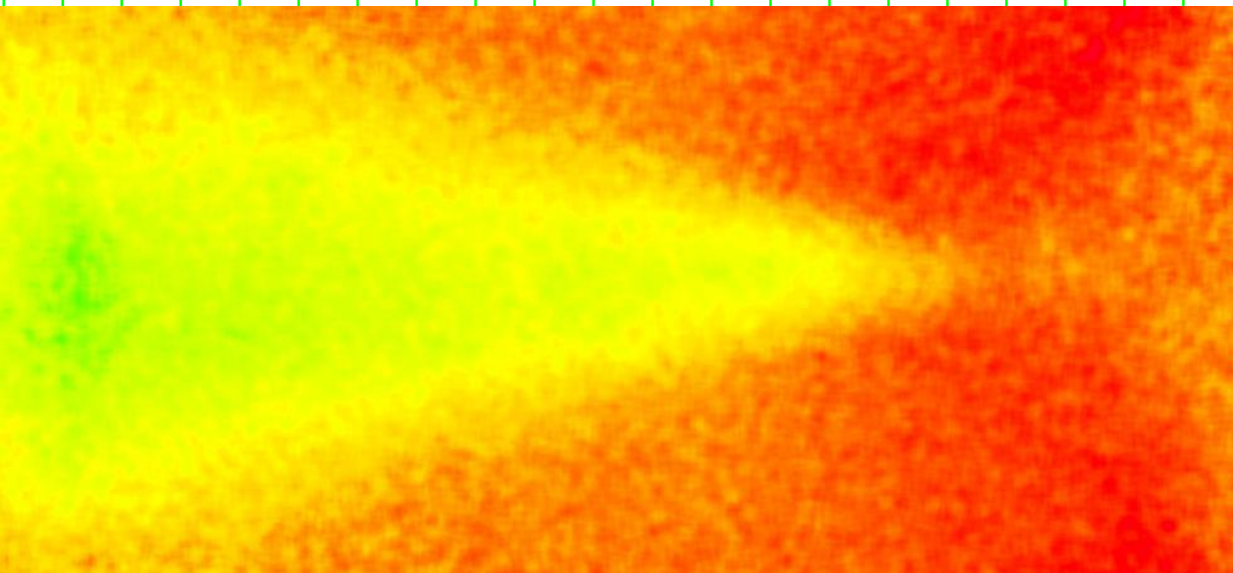
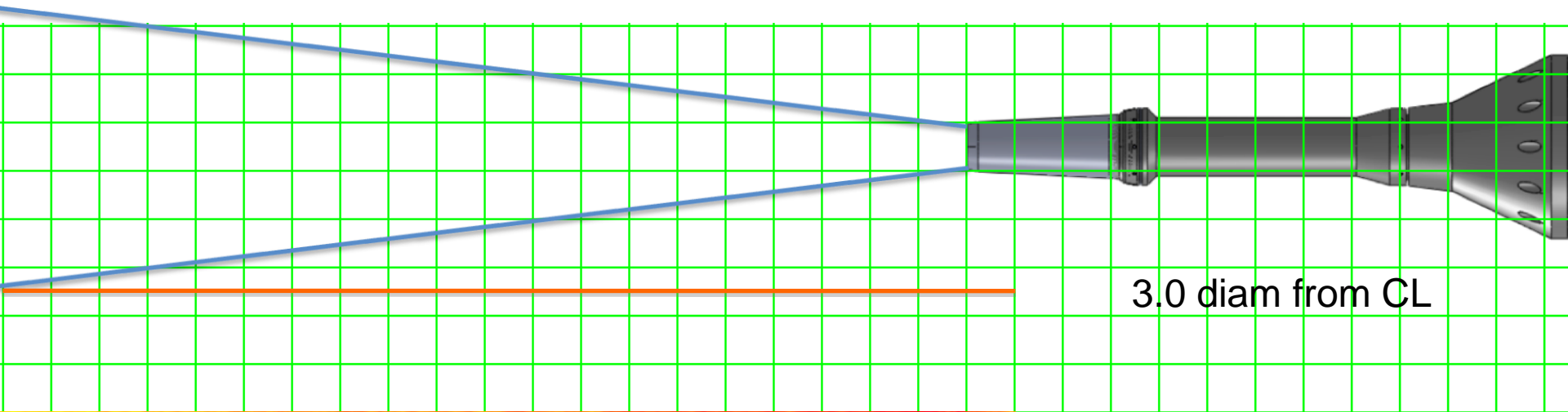
0.95



SMC016 CD Nozzle

Set Point 11606

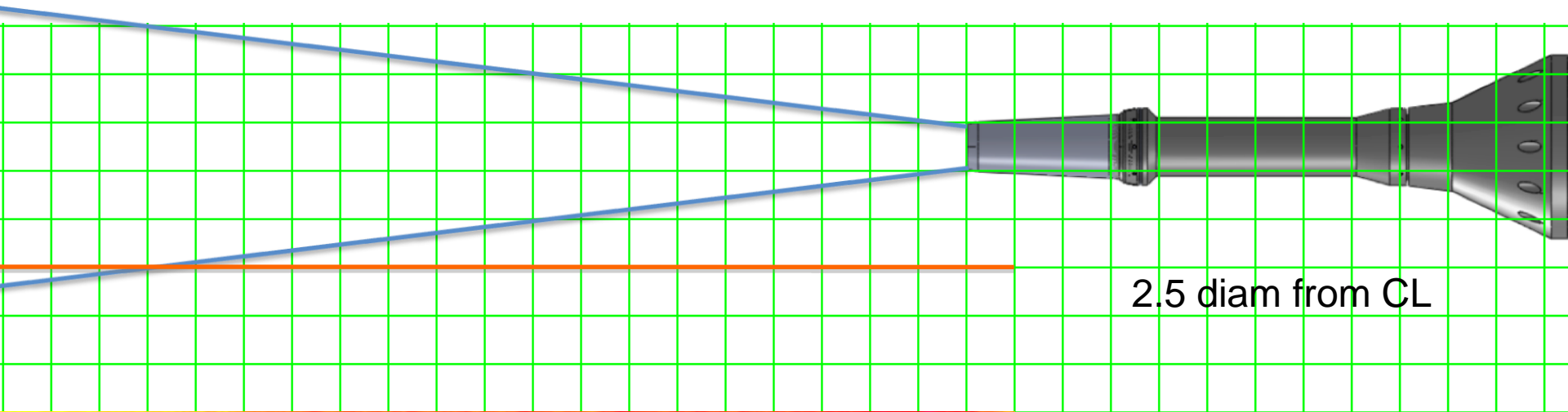
$M_{\text{jet}}=1.3$   $M_d=1.5$



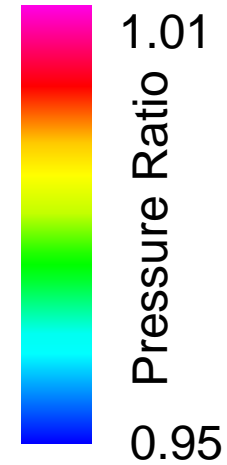
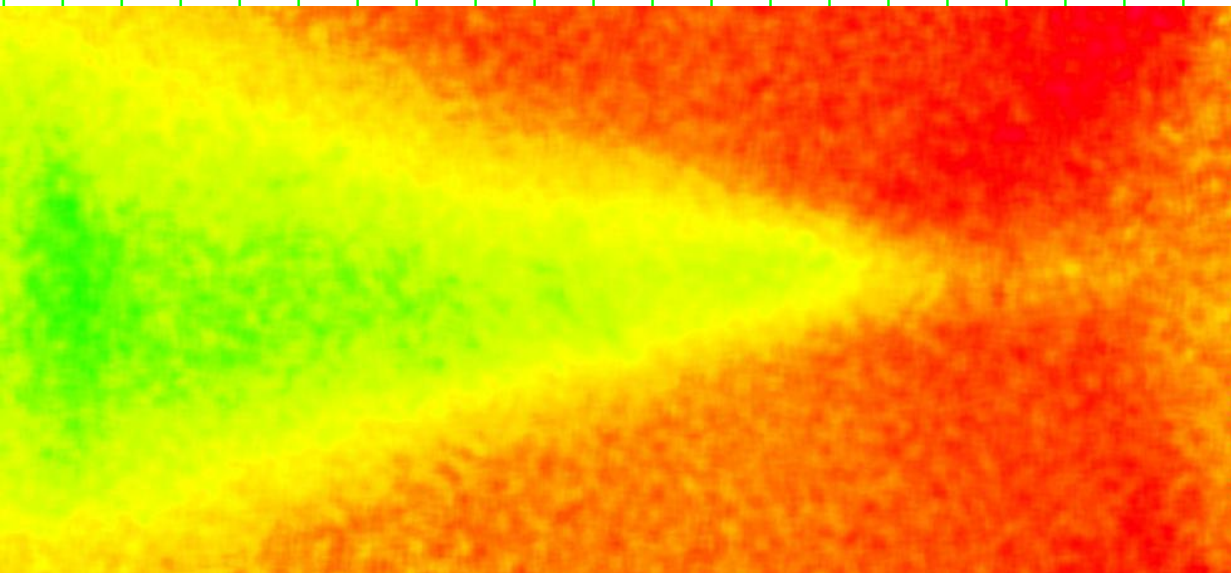
SMC016 CD Nozzle

Set Point 11606

$M_{\text{jet}}=1.3$   $M_d=1.5$



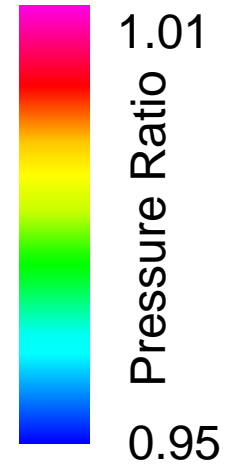
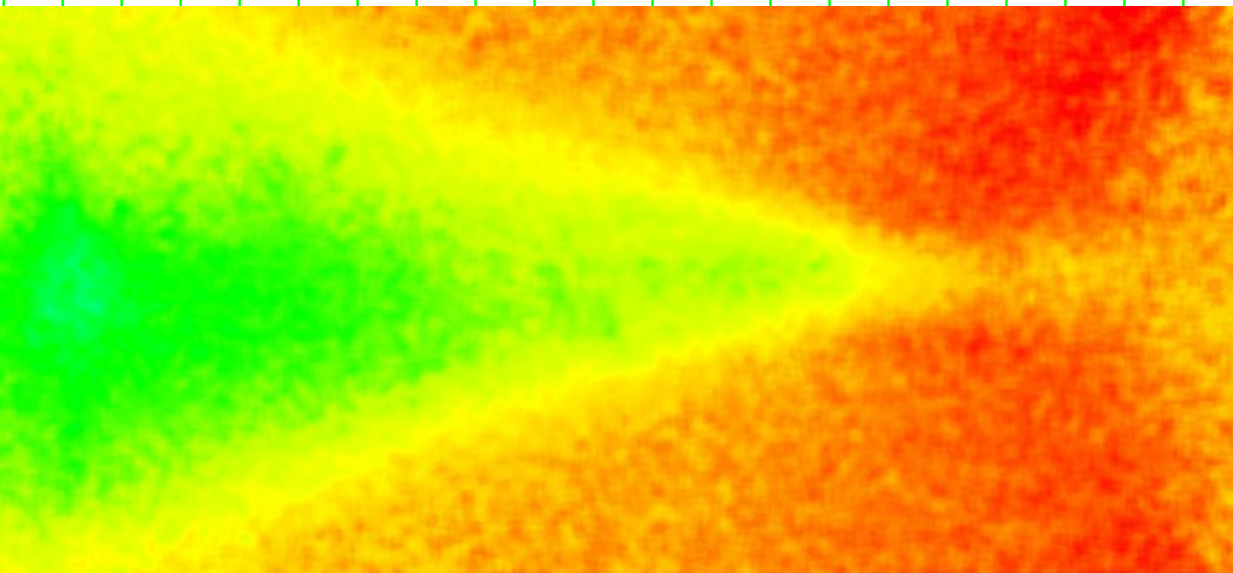
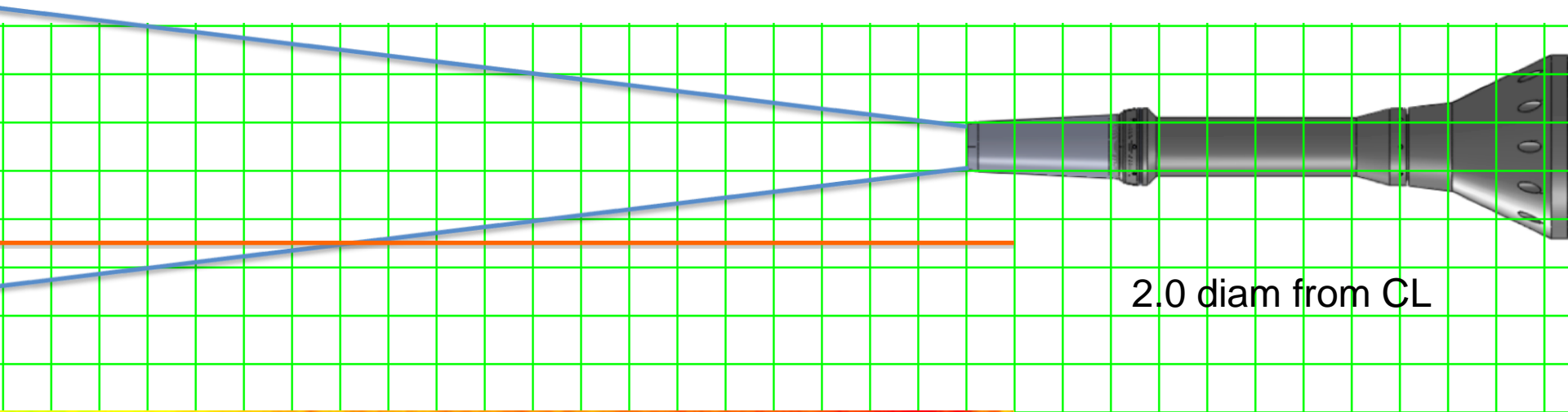
2.5 diam from CL



SMC016 CD Nozzle

Set Point 11606

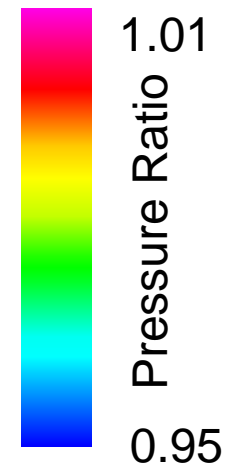
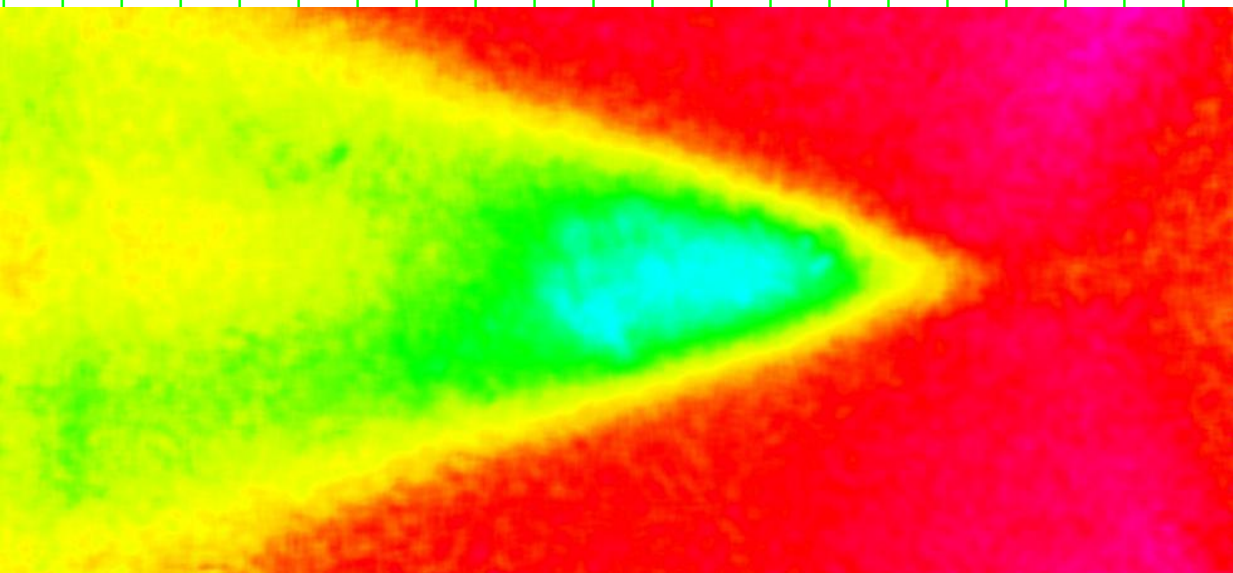
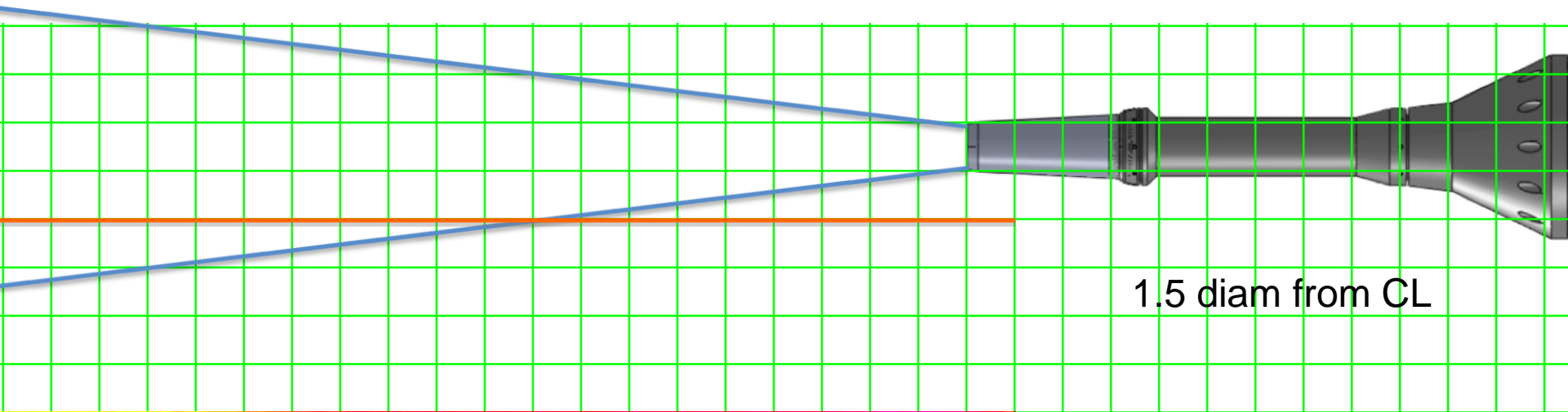
$M_{\text{jet}}=1.3$   $M_d=1.5$



SMC016 CD Nozzle

Set Point 11606

$M_{\text{jet}}=1.3$   $M_d=1.5$

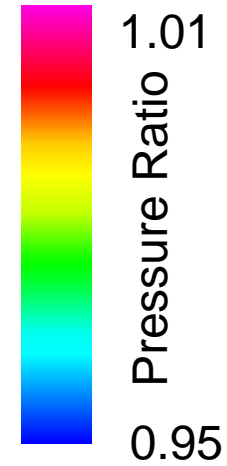
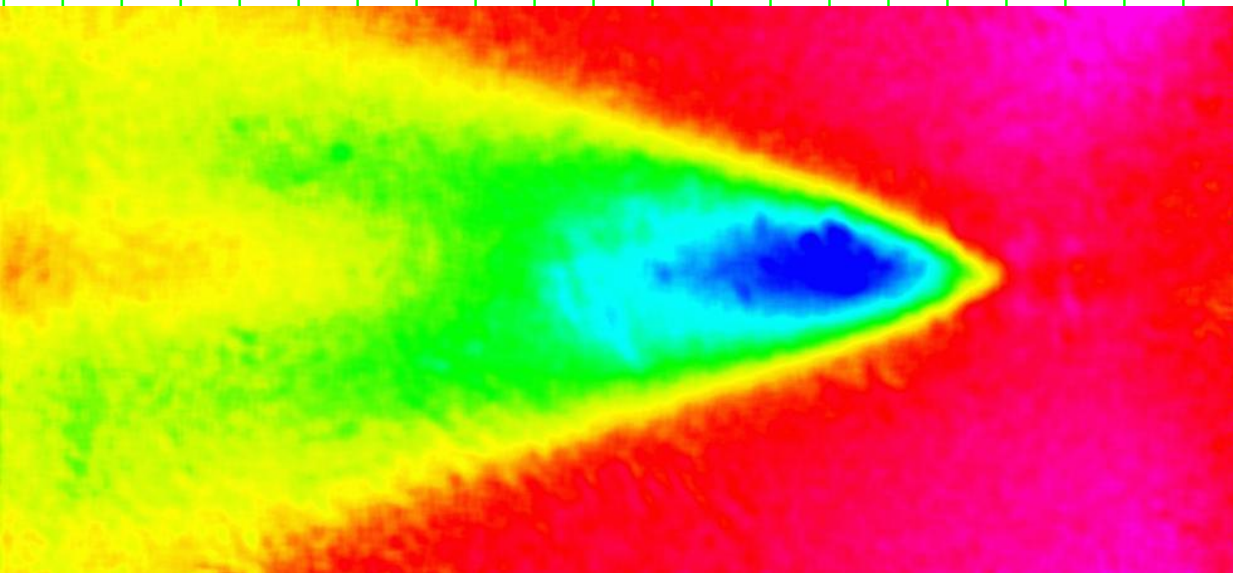
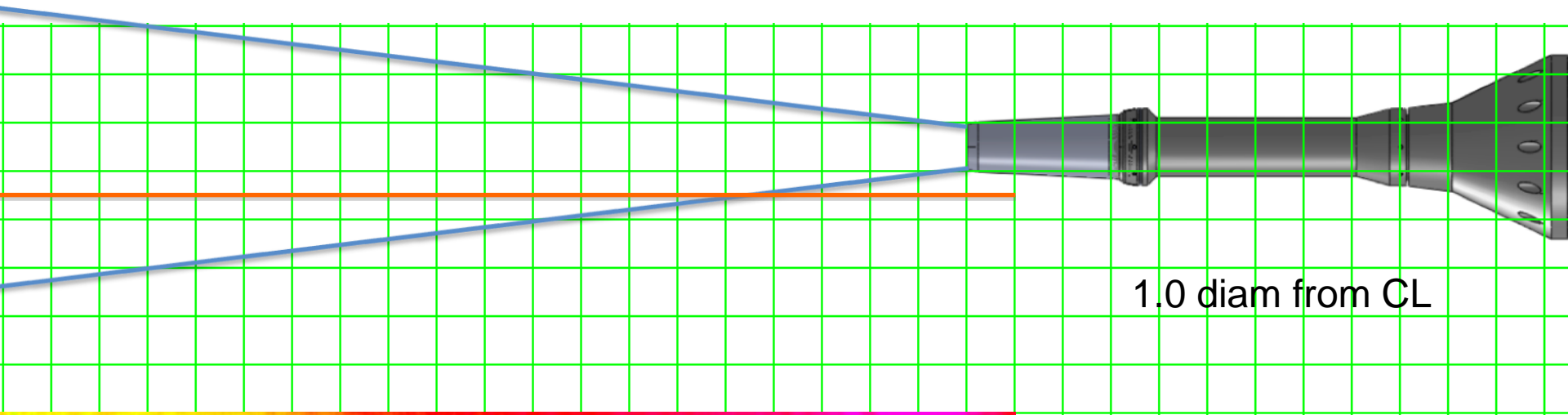




SMC016 CD Nozzle

Set Point 11606

$M_{\text{jet}}=1.3$   $M_d=1.5$





## Plans for JSIT2

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- 1) Unsteady surface pressure measurements very close to the surface TE
- 2) Hot jet data for reflecting surface configurations
- 3) Shielding surface phased array data with array in the peak noise direction
- 4) Reflecting surface phased array data both with and without the surface
- 5) PIV flowfield data near surface TE
- 6) Rectangular nozzles

Gary.G.Podboy@nasa.gov

Clifford.A.Brown@nasa.gov

